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Dear Sir/Madam:

The attached study was prepared in the Economic Analysis Directorate of the Strategic Planning Group of Transport Canada.

If you have any questions or comments on these forecasts, we would appreciate hearing from you.

The report is in translation and a french version will be available soon on request.

Yours sincerely,

Monsieur/Madame,

Le rapport ci-joint a été préparé par la direction de l'analyse économique du groupe de la planification stratégique de Transports Canada.

Si vous avez des questions ou commentaires en ce qui concerne ces prévisions, nous aimerions que vous nous en fassiez part.

Ce rapport est présentement en voie de traduction et une version française sera bientôt disponible sur demande.

Bien à vous

le directeur général
la direction de l'analyse économique

James R. Welch

J.R. Welch
Director-General
Economic Analysis Directorate

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TRANSPORTATION DEMAND AND OIL USE TO 1990

Economic Studies Division
DGEA
February, 1982

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EXECUTIVE SUMMARY

Background

The transport sector uses about half the petroleum consumed in Canada. Keeping this level of fuel use constant over the 1980s would be a major contribution to the government's objective of energy conservation. But what is the likelihood that such a target can be attained, given the potential growth in demand for transportation services? That question is the primary concern of this study.

To produce forecasts of fuel consumption, projections were made of the Canadian economy, energy prices, operating costs in the transport industry, technological progress in terms of fuel efficiency, and passenger and freight traffic. Two scenarios on world crude oil prices were used.

The Economy

Canada was spared the direct impact of energy price shocks in the 1970s. As a trade-dependent nation, however, Canada felt effects through its close ties with other countries. The problem of slow growth since 1974 has also been made worse by declining labour productivity. The country is now experiencing the direct effect of large energy price increases, in an environment of continuing slow growth, unemployment, high inflation and high interest rates.

For the forecast period to 1990, two scenarios on world crude oil prices were selected:

- average annual growth of 2% above the inflation rate, as assumed in the NEP/Alberta Agreement;

- average increase slightly below the inflation, at 8% a year.

Highlights of expected economic performance are:

- growth in GNP of 2.7% and 3% a year under the two scenarios, compared with 2.5% for the U.S.;

- low growth in personal disposable income per capita of 1.4% or 1.6% a year;

- average price increases (CPI) of 9.6% or 9.2%, compared with 8.9% in the U.S.;

- higher prices and lower growth in output and income to 1985, compared with the period 1985-90.

Fuel Prices and Costs

Motor gasoline prices, under the NEP/Agreement scenario, should reach 70 cents a litre by 1985 and $1.18 a litre by 1990 in current dollars. The alternative scenario would result in prices of 63 cents and 94 cents a litre by 1985 and 1990 respectively. In constant dollars, this is a total increase of 40% (NEP scenario) or 15% (alternate scenario) to 1990, over 1981 levels.

Increases to 1990 in real diesel prices given by the two scenarios are 44% and 19% for road, 70% and 34% for rail, and 79% and 37% for marine.

Marine bunker fuel prices in constant dollars are expected to rise by 89% or 44% to 1990, while turbo and aviation gasoline price increases of 73% or 37% and 41% or 19% are expected.

These price increases will mean significant growth in fuel costs. Under the NEP/Agreement scenario, fuel costs could reach 35% of total air operating costs, 30% for auto, 26% for marine for-hire, 19% for rail freight and 17% for for-hire trucking. If energy price increases occur that are similar to those included in the second scenario, fuel costs as a percentage of total operating costs are expected to be 31% for air, 26% for auto, 22% for marine, 16% for rail freight, and 14% for for-hire trucking.

A wide range of initiatives are anticipated to improve fuel efficiency, including vehicle modifications, increased load factors, and operational changes. These will vary by mode, with significant reductions in fuel use per passenger or ton kilometre occurring in automobile, air and truck.

Passenger and Freight Transport in the 1980s

On the basis of expected changes in costs and fares in the scenario of high energy prices, slow overall growth is expected in non-urban passenger travel: 1.5% a year on average to 1985 and 2.3% during the 10 years to 1990. Under the second scenario, with a more moderate increase in fares, growth of 2.2% to 1985 and 3% to 1990 is expected. Rail shows the most rapid growth reflecting improved service, and air the slowest growth resulting from the highest expected cost increases.

Little change is expected during the forecast period in the pattern of urban passenger travel and urban use of the automobile. Relatively rapid growth in population of driving age and in household formation will sustain the demand for automobiles, but at a lower rate of increase than in previous decades. Total auto kilometres are expected to increase on average at 2.8% a year from 1980 to 1990, with the strongest growth occurring within the major urban areas, at 3.4% per year.

Moderate growth in freight shipments of 3.4% on average per year is expected to 1990, with especially rapid growth for commodities such as grain, coal, potash, sulphur and iron ore. Increased shipments of grain through West Coast ports, relative to other ports in Canada, will result in higher fuel used per ton shipped. The major bulk commodity flows are relatively insensitive to changes in energy prices.

Fuel Consumption

This study focused on the initial acquisition or development of analytical and forecasting models, linking fuel use with transport demand and prices. Major data deficiencies exist, especially on road vehicles other than automobiles, and techniques need improvement, especially to forecast gasoline consumption.

Total gasoline consumption under the NEP/Agreement scenario is projected to fall to a level in 1985 which is 5% below that of 1980. In accord with improved general economic conditions and a slowdown in the rate of increase in gasoline prices, consumption of gasoline is expected to recover after 1985 and exceed the 1980 level by the end of the decade. Slower increases in prices (second scenario) indicate only a marginal decline in total gasoline use to 1985 from 1980 levels, and stronger growth thereafter to 1990.

A similar pattern of little or no growth to 1985 followed by more substantial increases in consumption to 1990 is expected for diesel. Growth will be stronger than for gasoline, as a result of continued switching to diesel use by road vehicles and because rail and marine freight tends to be less sensitive to changes in fuel prices.

In total, fuel used by the transport sector in 1985 is expected to be 6% below the 1980 level under NEP/Agreement prices and remain at the same 1980 level if the lower price scenario holds true. By 1990, however, total fuel consumption is projected to be higher than in 1980 in the first scenario and considerably higher (more than 10%) in the second.

Conclusion

The target of zero growth in fuel consumption by the transport sector should be attainable to 1985, as Canadians adjust to rapid increases in fuel prices.

Once the adjustment to world price levels has been made, renewed growth in fuel use is expected. From the present perspective, the more likely scenario is for slow world price increases, below the rate of inflation. As a result, fuel consumption by transport is likely to surpass the 1980 levels in the latter part of the decade.

Fuel use is sensitive to price, however, and the zero-growth target could be attained if the NEP/Agreement price levels were instituted, and the incentive retained for improved vehicle fuel efficiency, more conservation-conscious vehicle use, and off-oil programs.

Recommendations of the study include data development, fuel consumption model development and refinement, improved price and cost forecasting methods, a more rigorous approach to projecting the introduction of technological change, and continued close monitoring of fuel use in Canada.

1. INTRODUCTION

The major objective of this study was to determine likely levels of fuel consumption in the 1980s by the transport sector, and to compare these with the target level specified in the National Energy Program. Emphasis was put on the demand for passenger and freight traffic, arising out of the general socio-economic environment in the 1980s, and the development of methods and techniques suitable for ongoing analysis of fuel use. In particular, the forecasting methodology was designed to allow alternative scenarios on energy prices.

The approach is summarized in Figure 1. Apart from the intercity passenger and freight models existing in Transport Canada's Economic Analysis Branch (DGEA), analytical methods and models had to be developed or obtained elsewhere. Further refinement of these techniques was necessary and there were major data deficiencies. In the meantime, however, the objective was met with the tools and information available.

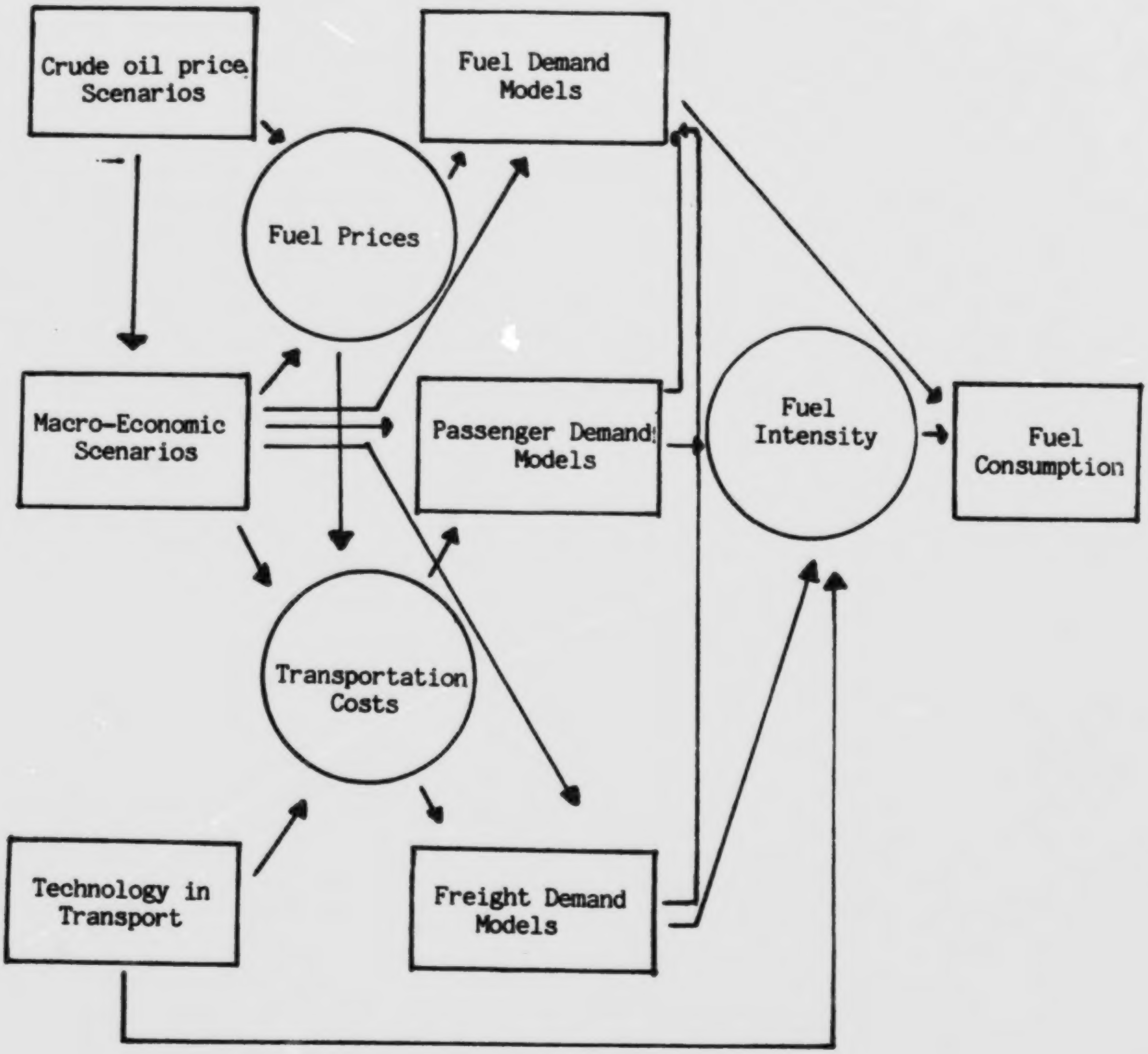
As a demand-oriented study, certain aspects of the energy issue were not examined, such as the availability and attractiveness of alternative fuels. Also, a key determinant of the blended domestic price of crude oil under the Alberta Agreement is the mix of crude from different sources, i.e., new conventional, old conventional, imports, synthetic crude plants; the likely mix resulting from the new pricing regime was not explored here. On the supply side in the transport industry, further efforts are required to assess the effect of high capital costs on the commitment to new fuel-efficient technology.

On the energy issue, there are many potential sources of instability or change which will not be captured by the analyst. The NEP's fiscal and pricing program extends only to 1986, and even before that date this institutional framework could be altered. Also, although Canada appears to be in a time of stable world oil prices, such stability can never be assured. Finally, current national economic policies may alter in response to the prospects of uncertain growth and high inflation, unemployment and interest rates.

This study, then, provides the best possible forecasts at the current time of the Canadian economy, energy prices, operating costs in the transport industry, technological progress in terms of fuel efficiency, passenger and freight traffic, and finally fuel consumption by transport. While improvements in data and analytical techniques will have to be made, the approach taken in this study permits the analysis of further scenarios on energy prices as the situation evolves.

FIGURE 1

SCHEMA FOR DGEA ENERGY FORECASTING STUDY


Crude oil price Scenarios
Fuel Demand Models
Fuel Prices
Macro-Economic Scenarios
Passenger Demand Models
Fuel Intensity
Fuel Consumption
Transportation Costs
Technology in Transport
Freight Demand Models

2. ENERGY AND THE CANADIAN ECONOMY IN THE 1980s

2.1 General

Canada is a net exporter of energy, but regional production and consumption imbalance calls for large quantities of crude oil imports. Unlike European countries since 1974, Canada's policy was to subsidize the price of crude oil to protect Canadians from unstable energy costs, especially those in regions relying on imports. The economic implications of maintaining Canadian oil prices below the world level, however, soon became evident. The development of new sources of supply was discouraged, as was the adoption of measures to conserve a scarce and exhaustible resource. For these and other reasons, such as an imbalance in energy revenues, the National Energy Program, a combination of scheduled price increases, fiscal measures and expenditure programs was introduced in 1980. This chapter examines what kind of economic conditions are likely in Canada during our forecast period to 1990 under this new energy policy.

Because of the policy of protecting the Canadian economy from the direct impact of world oil price shocks, other factors besides energy prices have perhaps contributed more to the slow overall growth in the Canadian economy. For example, Canadian labour productivity has been declining at an average annual rate of 0.1% since 1974. Current high interest rates and the government's tight monetary policy, aimed at containing inflation, have started to affect economic growth. However, as a result of even larger increases in oil prices than was envisaged in the NEP, the economy is now belatedly experiencing the oil crises. Transport is affected because not only is demand reduced by slowdowns in other sectors, but rapidly rising operating costs affect service levels, fares and, thus, demand. The transport sector consumes about 50% of the oil consumed in Canada, and alternate cheaper energy sources are not available to any extent in the short term.

What is likely to be the national socio-economic environment throughout the 1980s? Two scenarios on the world price of crude oil were chosen. For each case, the Informetrica model (TIM) of the Canadian economy was used to determine the performance of economic indicators such as income, inflation, and unemployment, which in turn affect the demand for transport. Underlying any projection of economic activity are certain key assumptions. In addition to the two energy price scenarios, which are explained in some detail below, there are other macroeconomic assumptions and these are described here in Section 2.3. A summary of the forecasts from TIM is then presented in Section 2.4.

2.2 Energy Price Scenarios

2.2.1 World Crude Oil Prices

a. Current Situation

The OPEC agreement on October 29, 1981, set a single base oil price of about $40 (Canadian) a barrel, ranging up to about $46 a barrel for higher-quality grades. This is an increase of about 15% over 1980 (see Figure 2). In constant dollars, the Persian Gulf price of oil has almost doubled from 1978 to the present. This has been a significant shock to the economies of most countries, although not as severe as that in 1973-74 when the real price almost tripled in a year.

b. Forecasts

The cartel members also agreed in October to a price freeze in 1982, which reflected low current levels of demand (dampened by recession and conservation measures) and excess supply as a result of the Saudi effort to regain control of OPEC by maintaining high production levels.

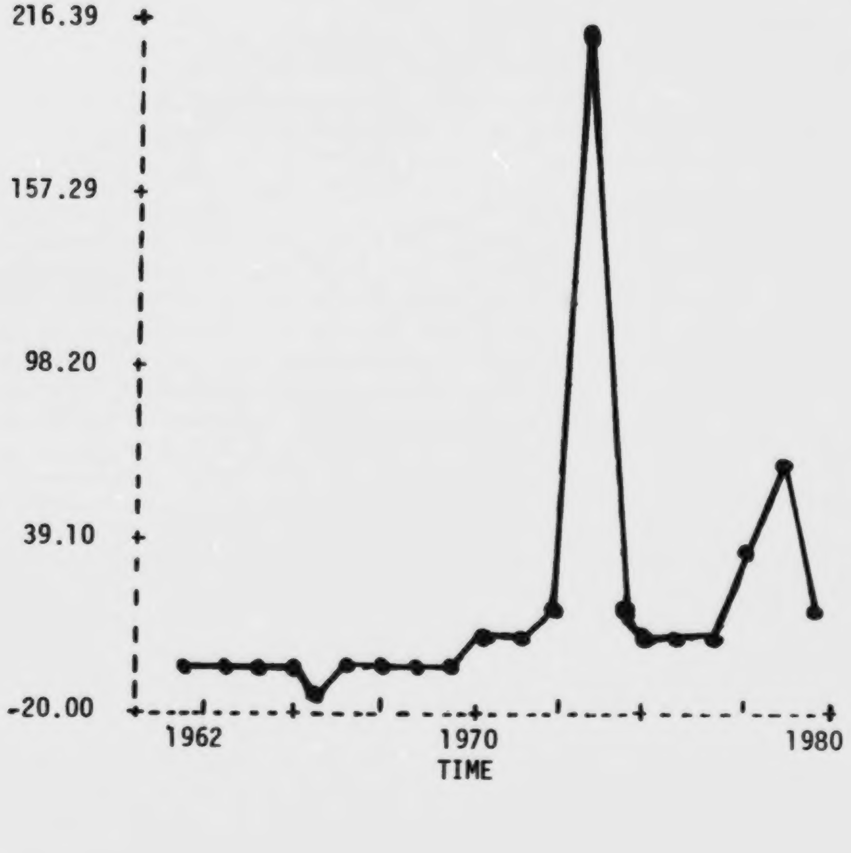
Saudi Arabia's apparent success in forcing reunification of OPEC's pricing structure may augur well for future stability. The price "hawks" (Iran, Libya, Algeria and Nigeria) may not again be as quick to increase their oil prices, as they were during the political instability between 1978 and 1980. Immediately after the OPEC agreement in October 1981, Saudi Arabia cut production by abOut a million barrels a day, stating that it would use its large oil production both to prevent breaches of the price freeze if demand was to increase, and to defend OPEC prices if demand remained weak. Its ability to do the latter now appears questionable.

Another development that may help to head off price shocks for consumers has been the ability of oil companies to diversify their sources of supply during the current glut. Mexico, for example, has become an important non-OPEC supplier, and companies have acquired exploration interests in other non-OPEC countries.

Although, as Saudi Arabia has claimed, a repeat of the two oil price shocks of the 1970s is unlikely in the 1980s, security in the supply of oil at reasonable prices can never entirely be assured. For forecasting purposes, this study assumes that such security and

FIGURE 2

PERSIAN GULF PRICE OF OIL (PERCENTAGE CHANGE)



absence of price shocks will exist in the 1980s.

In this study, two scenarios on world prices of crude oil (delivered at Montreal) were used (see Table 1). The first is the NEP/Agreement scenario which assumes that world prices will return to more rapid growth over the decade after the present temporary lull. But, some analysts believe that oil price increases will barely keep up with the general inflation rate, and so a much lower rate of growth was assumed for the second scenario. These assumptions are presented in more detail below in Section 2.2.2.

2.2.2 Canadian Crude Oil Prices

a. General

The 1980 National Energy Program emphasized the need to shield Canadians from "uncertain and erratic movements in world oil prices", and affirmed the Government's commitment to:

> "a single price for crude oil in Canada, subject to transportation differences, and gradual increases in that price in order to foster the development of new supplies and encourage conservation, while allowing Canadian consumers time to adjust".

The principles underlying the development of that single price were established in the NEP. It was to be a blend or weighted average of the costs of different sources of oil. The Memorandum of Agreement signed by the federal and Alberta governments on September 1, 1981, reaffirmed this pricing system with some modifications and established schedules for increases in domestic oil prices to 1986.

Thus, the price to be paid by Canadians for crude oil is a blend of the price of imported oil and the prices of old conventional oil, new conventional oil and synthetic crude produced in Canada.

b. Component Prices and Forecasts

The price of imported oil to be used in calculating the blended price is that which would be paid in Montreal, and consists of:

- an average world price in U.S. dollars, weighted to reflect the specific sources of oil to Canada;
- conversion to Canadian dollars by the exchange rate;

TABLE 1

CRUDE OIL PRICES TO 1990, TWO SCENARIOS

	Alberta Agreement/NEP		Slower Growth in World Prices	
	Int'l Price at Montreal	Blended Price at Montreal	Int'l Price at Montreal	Blended Price at Montreal
	($/barrel on July 1)			
1981	43.80	30.06	43.80	30.06
1985	71.80	60.18	59.60	51.50
1990	118.80	108.15	87.55	80.75
	(% p.a.)			
1981-85	13.2	19.0	8.0	14.4
1981-90	11.7	15.3	8.0	11.6

In Constant Dollars

	($/barrel on July 1)			
1981	43.80	30.06	43.80	30.06
1985	49.60	41.57	42.05	36.33
1990	54.25	49.40	41.38	38.17
	(% p.a)			
1981-85	3.2	8.4	-1.0	4.9
1981-90	2.4	5.7	-0.6	2.7

- transportation costs to Portland and from there to Montreal.

Under the Alberta Agreement, this Montreal price of imports was assumed to increase by 12 1/2% a year to 1986 or at 2.4% in real terms. This was the same rate of increase as was assumed for the National Energy Program in 1980, and so the DGEA forecast also used the NEP assumption of slightly slower growth from 1986 to 1990. Under the second scenario, the price of imports landed at Montreal was assumed to increase at 8% a year in current dollars on the average during the forecast period to 1990 (see Table 1).

Increases in the price of old conventional oil, as for all sources of domestic crude, were specified to 1986 in the Alberta Agreement. At the wellhead, these increases for conventional oil discovered before January 1, 1981, were to average 22% a year, with the most rapid growth occurring to 1983. A ceiling was imposed, however at 75% of the world price (at Montreal). Under the Agreement scenario, this was not to have been reached until 1986. Under this study's alternate scenario on world prices, the ceiling is met in 1984, so that growth before 1984 averages more than 23%, while from 1984 to 1990 it is 8% a year. From 1986 to 1990, for both scenarios, the 75% ceiling is assumed to remain government policy.

The price of new conventional oil, discovered in 1981 or thereafter, and synthetic crude was to follow a schedule called the New Oil Reference Price (NORP). This schedule matches the assumed price of imports at Montreal (column 1, Table 1). A ceiling at 100% of the actual international price was also specified, and provision was made for higher levels than the NORP for new conventional oil from January 1, 1985, and earlier for syncrude, in the event that a phased-in moving average of actual international prices exceeded the NORP. For the period from 1986 to 1990, it was assumed here again that the ceiling will remain in effect.

c. Blended Price for Canadians

This is the price actually paid by refiners in Canada and, apart from transportation costs, is the same across the country. The blending mechanism, the Petroleum Compensation Charge, was introduced with the NEP and set at pre-specified levels. In the September agreement, however, this charge was no longer fixed, but was to be only sufficient to cover the extra cost of imports and new conventional or synthetic oil. No longer could surplus revenues be generated by the federal government if, for example, the amount of imported oil dropped.

The blended price is now, therefore, a pure weighted average of import and domestic prices, with the weights representing the consumption of oil from each source. Under the new price schedules for domestic producers, what then will be the mix of old conventional, new conventional, enhanced recovery and synthetic crude and what will be the import requirement?

Unfortunately, these demand and supply effects were not examined for the Agreement and still appear uncertain. Pricing at world levels should stimulate an expansion of new conventional oil supplies and progress on the new oil sands plants. On the other hand, producers continue to maintain that the revenue split under the Ottawa-Alberta pact leaves insufficient funds for them to make the necessary investments for new oil. Similarly, the possibility of self-sufficiency in oil by 1990, an objective of the NEP, has been questioned by the recent National Energy Board report on supply and demand to the year 2000.

The National Energy Board's "middle case" demand forecast, consistent with the views of most submissions to the Board, has crude oil requirements in 1990 down by a total of 0.2 million barrels per day over 1980. In the Ottawa-Alberta Agreement, it was assumed that consumption would fall from 1.8 million in 1980 to 1.6 million by 1986. This was the same projection that was made for the NEP where, by 1990, consumption was expected to be down to 1.5 million barrels a day.

On the supply side, the NEB "modified base case" has production falling from the 1980 level of 1.54 million barrels per day to 1.24 million barrels in 1986 and then climbing to 1.45 million barrels a day in 1990. As a result, imports will average about 10% of consumption in the latter part of the 1980s. Under the NEP/Agreement scenario, however, production in 1990 was equal to 1.5 million barrels a day, implying self-sufficiency.

The NEB scenario has 35% of productive capacity in 1990 contributed by the oil sands, as a result of an expansion of Syncrude and construction of the Cold Lake and Alsands plants. Conventional light oil would contribute another 35%. The breakdown was similar in the NEP. Delay in the two new oil sands projects, however, was incorporated in the expected production mix under the Alberta Agreement, with oil sands production accounting for just 10% of the total in 1986.

To calculate the expected blended price of crude oil in Canada to 1990, assumptions had to be made about total consumption, production, exports and imports, plus the mix of sources of domestic production. Up to 1986, the Agreement scenario was used. This was identical to the NEP for consumption and exports, somewhat higher for compensable imports and lower for production. The NEP scenario for consumption and exports was continued to 1990, the National Energy Board's production growth and mix from 1986 to 1990 were used, and imports were estimated residually.

Using these assumptions together with scheduled price increases for domestic crude, from its various sources, and the NEP/Agreement forecast price of imports, the blended or Canadian price at Montreal was calculated to 1990 (column 2 of Table 1). Altering the price of imported crude resulted in the second set of Canadian prices in the Table.

2.2.3 Other Canadian Energy Prices

Prices of other energy sources are important in determining the consumption of oil. While the transportation sector is largely locked into the use of oil, the success of off-oil programs and substitution among fuels in other sectors will affect the availability of fuels for transportation.

A reduced market share for oil can occur from either a switch by consumers in those areas where substitutes already exist or a switch to newly available alternative energy sources. The provision of grants for homeowners to convert from oil heating will encourage the first, and the expansion of the gas pipeline to areas east of Montreal will introduce gas sales in these new markets.

In addition to these developments, expansion of the natural gas market in Canada should result from the gas pricing scheme established in the Ottawa-Alberta Agreement. Under that Agreement, the Alberta border price of gas will increase by 50 cents per mcf a year to 1986, and Alberta will pay to the federal government 30% of the revenues they receive in markets east of Alberta from sales of gas in excess of a specified quantity. This was called an "incentive payment", to be used for the developing and servicing of new gas markets.

Also, the wholesale price of gas at the Toronto City Gate, which includes pipeline and pipeline extension tariffs, is to be held at about 65% of the wholesale price of crude oil at the Toronto Refinery Gate. This is administered by the federal government's Natural Gas and Gas Liquids Tax and ensures a favorable consumer price relative to oil.

Prices of other energy commodities were not included in the Agreement and have not been studied here. For the energy sub-model of the Informetrica Model (TIM), the average domestic price of coal

TABLE 2

ECONOMIC GROWTH (1) OF CANADA'S MAJOR TRADING PARTNERS
(% real average annual growth)

	1962-73	1974-80	1981-90	1981-85	1986-90
	ACTUAL		FORECAST		
U.S.	4.3	2.4	2.5	2.3	2.7
EEC	5.3	2.1	3.0	2.8	3.1
JAPAN	11.2	3.0	5.0	4.8	5.2

---

(1) GNP for the U.S., industrial production for the EEC and Japan.

TABLE 3

U.S. INTEREST RATES AND PRICES
(% average annual growth)

	1968-72	1973-80	1981-90
	ACTUAL		FORECAST
Interest rates (1) (level)	7.6	9.8	13.3
CPI	4.6	9.0	8.9
GNE Price Deflator	4.8	7.9	8.6

---

(1) Total U.S. Bond Rate

TABLE 4

NOMINAL AND EFFECTIVE CANADIAN EXCHANGE RATE

	1972-76	1977	1978	1979	1980	1981	1982-90
$U.S. per $Cdn	1.01	.94	.88	.85	.86	.83	.85
Effective (1) Exchange Rate (1970 Q1=100.0)	99.0	91.0	87.8	87.5	84.9	86.9	N.A.

---

(1) Trade weighted exchange rate

TABLE 5

CANADIAN ECONOMIC PERFORMANCE TO 1990 - TWO SCENARIOS
(% average annual growth)

		1980-85	1985-90	1980-90
GNE	I	2.3	3.2	2.7
	II	2.6	3.3	3.0
Productivity	I	0.4	0.7	0.5
	II	0.5	0.7	0.6
Employment	I	2.0	2.1	2.0
	II	2.1	2.3	2.2
GNE Deflator	I	10.7	9.4	10.0
	II	10.2	9.0	9.6
CPI	I	10.6	8.6	9.6
	II	10.1	8.3	9.2
Consumption	I	2.0	2.8	2.4
	II	2.3	3.1	2.7
Personal Disposal Income per Capita	I	1.0	1.9	1.4
	II	1.3	2.0	1.6
Exports	I	2.6	3.7	3.2
	II	2.7	3.9	3.3
Imports	I	3.7	2.4	3.1
	II	3.7	2.5	3.1

		1980	1981	1985	1990
Unemployment	I	7.5	7.5	8.0	5.4
	II	7.5	7.5	7.5	4.3
Interest Rates[1]	I	13.2	15.7	12.0	10.5
	II	13.2	15.7	12.0	10.5

---

[1] Average yield for 10 industrial bonds.

was linked to the Toronto price of oil, and the average price of electricity was related to the output price for electric power rather than the international oil price.

2.3 Other Assumptions Underlying the Macroeconomic Forecasts

2.3.1 General

Assumptions used were agreed upon by DGEA and the Ministry of State for Economic Development, a partner in developing the basic scenario. This subsection first examines the external assumptions, or those related to the influence on Canada of other countries, and then assesses domestic demographic and policy assumptions.

2.3.2 External Assumptions

Canada is one of the world's most trade-dependent nations. Exports account for some 25% of Gross National Expenditure, with the largest markets being the U.S., Western Europe and Japan, in that order. Accordingly, the economic outlook of Canadian trading partners' economies and the exchange rate are important factors.

In most OECD countries, the economic recovery that started in late 1980 and was sustained in early 1981 has now leveled off. DGEA assumptions of economic growth among our trading partners are in Table 2.

Another major influence is the U.S. interest rate. The U.S. is now fighting inflationary pressures mainly with restrictive monetary policies. For the purposes of the DGEA projections, it was assumed that interest rates in the U.S. will remain high over the decade. This reflects their inflation rate, which will subside but still remain relatively high (see Table 3). The U.S. inflation rate, which affects Canada through import prices and multinational wage settlements for example, is expected to moderate because of the improving climate in international oil markets and because higher U.S. unemployment will keep a lid on wage demands.

The Canadian dollar is assumed to rise marginally in value relative to the U.S. dollar (see Table 4). This is based on the assumption that world prices for resource products, of which Canada is a net exporter, will be rising faster than prices of manufactured goods, of which Canada is a net importer.

2.3.3 Domestic Assumptions

DGEA has used Statistics Canada population projections, showing a slowdown to 1990 in growth of the working-age population (assuming net immigration of 50,000 a year to 1984 and 60,000 a year to 1990). This should limit growth in the labour force participation rate, which grew rapidly during the 1970s, such that it reaches only 68% by 1990, compared with 64% in 1980.

No major fiscal policy change is assumed over the long run to 1990. For example, the government is expected to use the growing receipts from larger oil revenues to reduce its deficit rather than to decrease tax rates or increase government spending. The Bank of Canada's current policy of keeping interest rates high to contain inflation will prevail as long as high rates of inflation persist.

2.4 Macroeconomic Forecasts

During 1980-85, growth in the Canadian GNP will average 2.3% annually in the base case or NEP/Agreement scenario (see Table 5); in the second scenario, 2.6% annually. Annual growth in real personal disposable income per capita will be low, at 1% in the first scenario and 1.3% in the second. A contributing factor will be lower employment growth, as in both scenarios projected growth in employment is only about 2% annually. The rate of unemployment will remain high, at about 8% in 1985 in the base scenario, versus 7.5% in the second scenario. This reflects the slow overall economic growth and under-utilization of the labour force.

Higher price increases for food, energy and services, particularly shelter, will be reflected in an average CPI of 10.% in the base case scenario and 10.1% in the second. Average growth in total consumption in the economy for the two scenarios will be 2% and 2.3% during 1980-85.

Imports will grow faster than exports in both cases, at 3.7% annually, down from 4.9% in 1981. Much of this growth, however, will be in higher interest and dividend payments to non-residents. Imports of goods will be restrained by the slow domestic economy.

Average annual growth in exports, 4.4% in the 1980-81 period, will in both cases slow to about 2.6% over 1980-85. Here some explanation is in order. The OECD countries and the U.S., Canada's chief trading partners, are likely to be still practicing restrictive economic policies, and while some recovery in Canadian crude and semi-fabricated export materials will occur over 1980-85, a sharp decline in exports of manufactured goods such as automotive products is anticipated.

The latter half of the decade, 1985-90, will see some recovery. Average economic growth will be almost identical under both energy price scenarios, 3.2% and 3.3%, and real personal disposable income per capita will be rising at 1.9% annually in the first case and 2.0% in the second. Growth in total employment will still be only moderate, at 2.1% in the first case and 2.3% in the second, but the unemployment rate will fall considerably, reflecting slower growth in the labour force. In 1990 an unemployment rate of 5.4% is expected under the first case, and only 4.3% under the second.

The CPI will still show relatively high growth in 1985-90, at 8.6% in the first place and 8.3% in the second. (The gap between the CPI in the two cases narrows relative to 1980-85 because the NEP scheduled price increases have their greatest effect in the early 1980s). Total consumption will rise at a faster rate than during 1980-85, at 2.8% and 3.1%. This is considerably below historical rates, but consistent with lower population and employment growth.

While import growth will fall off to about the same rate in both cases, 2.4% and 2.5%, exports will become a major source of growth in the economy. Causes include economic recovery in the U.S., continued improvement in Canada's energy exports and price increases for Canadian raw materials. In the base case, exports will grow at 3.7% over 1985-90; in the second case, at a higher rate of 3.9%.

To summarize, over the forecast period to 1990, this study expects a slow-growth, moderately high-price economy. Under both scenarios on energy prices, it will generate new jobs at only about 2% per year over the decade, and despite government efforts, price increases will stay high. The rise in energy prices, continuing high interest rates, and a persistent trend towards wage increases exceeding productivity gains and inflation, will be contributing factors. Forecasts for selected indicators are contained in Table 5.

3. FUEL PRICES TO 1990

3.1 General

The method employed by the Department of Energy, Mines and Resources (EMR) to project fuel prices in transport under the National Energy Program was independent of the department's supply or demand forecasts. A modified and expanded version of this approach has been used in this study. Where EMR projected only four prices (gasoline, road and off-road diesel and marine fuel), this study has included these and added aviation gasoline (see Tables 6, 7). In addition, EMR used 1979-80 as a base and did not incorporate recent ad valorem taxes on road fuels. This study has been able to incorporate more recent information. The following section examines fuel prices on a mode-by-mode basis, referring to the EMR results for comparison, and uses the two scenarios described before.

3.2 Gasoline

The method employed here is similar to that used by EMR in a re-estimation done after the Alberta Agreement. The final price is generated by adding:

- the July 1 Toronto blended crude oil price for the year in question;
- a refinery margin based on 1981 experience;
- a 9% federal sales tax;
- a retail margin based on 1981 experience;
- a federal excise tax of 1.5c/litre;
- the provincial sales tax, estimated at 20%.

For succeeding years the method is the same: a projection based on the crude oil price as of July, except that the producer and refiner margins are inflated at projected CPI. The projection as done by EMR ended in 1986; here it has been extended to 1990. The results for the Agreement scenario are practically identical to those in an EMR projection done after the Alberta Agreement: a nominal price to 79c per litre by 1986, rising to $1.18 a litre by 1990. The second scenario would bring a corresponding price of 63c and 94c.

TABLE 6

PROJECTED GROWTH RATES FOR TRANSPORT FUEL PRICES, CURRENT DOLLARS

	1980-1981	1981-1985	1980-1990
	(average annual percentage growth)		
Motor Gasoline			
NEP	23.0	12.8	12.6
DGEA: Agreement	41.0	15.8	17.0
: Second Scenario	41.0	12.7	14.4
Road Diesel			
NEP	23.3	13.3	12.9
DGEA: Agreement	61.0	16.5	17.7
: Second Scenario	61.0	13.3	14.9
Off-Road Diesel			
NEP	29.6	15.1	14.6
DGEA: Agreement	41.3	20.5	18.1
: Second Scenario	41.3	16.6	14.9
Marine Bunker			
NEP	38.7	17.3	16.7
DGEA: Agreement	50.0	22.6	20.0
: Second Scenario	50.0	17.9	16.4
Aviation Turbo			
NEP	29.6	15.1	14.6
DGEA: Agreement	35.7	21.1	17.8
: Second Scenario	35.7	17.1	14.7
Marine Diesel			
DGEA: Agreement	41.3	20.5	18.1
: Second Scenario	41.3	16.6	14.9
Aviation Gasoline			
DGEA: Agreement	34.8	16.7	15.4
: Second Scenario	34.8	13.8	13.0

TABLE 7

FORECAST PRICES IN CENTS PER LITRE, CURRENT ($C) AND CONSTANT 1981 ($K) DOLLARS, OPTIMISTIC AND PESSIMISTIC FORECASTS*

	MOTOR GASOLINE				ROAD DIESEL (Bus, Truck)			
	Pessimistic		Optimistic		Pessimistic		Optimistic	
	$K	$C	$K	$C	$K	$C	$K	$C
1979	26.5	21.1	26.5	21.1	24.7	19.7	24.7	19.7
1980	28.0	24.5	27.9	24.5	26.4	23.1	26.3	23.1
1981	38.8	38.8	38.8	38.8	37.2	37.2	37.2	37.2
1982	40.7	45.5	40.1	44.7	39.4	44.0	38.7	43.2
1983	43.7	53.7	42.2	51.4	42.6	52.3	41.1	50.0
1984	46.3	61.7	43.8	57.6	45.4	60.5	42.8	56.3
1985	48.1	69.7	44.1	62.6	47.3	68.5	43.2	61.3
1986	50.0	78.6	44.5	68.1	49.3	77.6	43.7	66.9
1987	51.6	87.9	44.6	73.8	51.1	87.1	43.8	72.6
1988	51.9	96.1	44.6	80.0	51.5	95.4	44.0	78.9
1989	52.9	106.3	44.5	86.6	52.6	105.8	44.0	85.6
1990	53.8	117.8	44.3	93.7	53.7	117.5	43.9	92.8
	RAIL DIESEL				AVIATION TURBO			
1979	15.6	12.4	15.6	12.4	19.6	15.6	19.6	15.6
1980	18.3	16.0	18.3	16.0	22.7	19.9	22.7	19.9
1981	22.6	22.6	22.6	22.6	27.0	27.0	27.0	27.0
1982	26.6	29.7	26.1	29.1	32.3	36.1	31.7	35.4
1983	29.2	35.8	27.9	34.0	35.4	43.5	33.9	41.3
1984	31.4	41.8	29.2	38.4	38.1	50.8	35.5	46.7
1985	32.9	47.7	29.5	41.8	40.1	58.0	35.8	50.8
1986	34.6	54.4	29.8	45.7	42.0	66.1	36.3	55.5
1987	36.2	61.6	30.1	49.8	43.9	74.8	36.5	60.5
1988	36.6	67.8	30.3	54.4	44.5	82.4	36.8	66.1
1989	37.6	75.6	30.4	59.1	45.7	91.9	36.9	71.8
1990	38.5	84.4	30.4	64.3	46.8	102.5	36.9	78.1
	MARINE DIESEL				MARINE BUNKER			
1979	18.5	14.7	18.5	14.7	12.3	9.8	12.3	9.8
1980	19.6	17.2	19.6	17.2	13.5	11.8	13.5	11.8
1981	24.3	24.3	24.3	24.3	17.7	17.7	17.7	17.7
1982	28.5	31.9	28.0	31.2	21.6	24.1	21.0	23.4
1983	31.3	38.4	29.9	36.4	24.0	29.5	22.7	27.7
1984	33.7	44.9	31.3	41.2	26.1	34.8	24.0	31.5
1985	35.4	51.2	31.7	44.9	27.6	40.0	24.1	34.2
1986	37.1	58.4	32.0	49.0	29.2	46.0	24.6	37.6
1987	38.8	66.1	32.3	53.5	30.9	52.6	24.9	41.2
1988	39.3	72.7	32.5	58.3	31.4	58.1	25.1	45.1
1989	40.3	81.1	32.6	63.5	32.5	65.3	25.3	49.2
1990	41.3	90.5	32.6	69.0	33.4	73.2	25.4	53.7
	AVIATION GASOLINE							
1979	29.1	23.2	29.1	23.2				
1980	30.8	27.0	30.8	27.0				
1981	36.4	36.4	36.4	36.4				
1982	39.5	44.2	39.0	43.5				
1983	42.3	52.0	41.1	50.1				
1984	44.8	59.7	42.7	56.2				
1985	46.5	67.4	43.1	61.1				
1986	48.2	75.8	43.5	66.6				
1987	49.6	84.6	43.5	72.1				
1988	49.9	92.4	43.5	78.1				
1989	50.7	102.0	43.5	84.6				
1990	51.5	112.7	43.2	91.5				

* "Pessimistic" is the NEP/Agrement scenario, "optimistic" is the scenario with smaller increases in world crude oil prices.

An implicit assumption is that margins will decline over time as a proportion of the final selling price, because, while the price of domestic crude will rise and the taxes imposed are ad valorem, the margins themselves will only rise at the rate of inflation. This assumption may not be entirely correct. There have been some indications in 1981 that refineries are passing along crude oil price increases at a more rapid rate than this method anticipates, but more "tracking" of future increases will be needed before any definitive conclusions can be drawn.

Regional prices were generated in essentially the same manner, except that differences in transportation cost were reflected in the crude prices by region. For provinces west of Ontario,the blended price was taken as that in Toronto less the transportation charge to Toronto, and in provinces east of Ontario, the blended price at Montreal was used. Regional refinery and retail margins were derived using inadequate information. Margins were adjusted to account for the difference between regional crude prices at the pump, with federal taxes and appropriate regional road taxes also taken into account (see Table 8).

3.3 Bus and Truck Diesel

Both of these modes are considered to use diesel from roadside retailers. Some larger companies may in fact obtain fuel directly from refineries, but probably not at the discounts received by larger rail and marine buyers, and at least some fuel is purchased by the roadside. This implies refinery and retail margins as in gasoline. A "pre-discount" selling price from the refinery is adjusted upward by the federal sales tax, then the retailer's margin is added, and finally the provincial road tax. In the price series constructed by EMR for the National Energy Plan, the road diesel price was apparently derived in a similar manner to the gasoline price. The EMR series did not employ ad valorem provincial tax assumptions on diesel, however, and assumed that the relative value of taxes would fall. The ad valorem assumption, plus revised assumptions on the price of crude oil, make a considerable difference in the price to be expected in 1990. The EMR result in 1990 was about 76c a litre, nominal. The present study obtains $1.18 in the first scenario and 93c in the second, or a nominal annual average growth of 17.9% or 15.5% since 1979, versus the National Energy Program's 13.1%.

There is no monthly survey of retail diesel prices, as there is of gasoline prices, which makes a current price difficult to obtain. Similarly, Statistics Canada series on values and quantities of fuels used in the bus and truck industries are inconsistent and not detailed enough to use as a historical series. The July 1981 price of 38.8c/litre is based on an average of provincial information provided by the Energy Statistics Branch of Energy, Mines and Resources. Margins were calculated "backwards" from this, with an assumed provincial ad valorem tax rate of 23% added on at the retail level. This is an average of those in the various provinces, which range from 0% in Alberta through 27% in Ontario and Newfoundland to 29% in Prince Edward Island. The retail margin is assumed to be the same as that for gasoline (2.9c/litre or 8% of price). The 9% federal sales tax is taken off and the refinery margin is taken as the difference between the remainder and the crude oil price. The refinery margin figure thus derived for July 1981 was 6.3c/litre, is a little less than that on gasoline.

The retail price of road diesel in 1990 (93c in the second scenario) is projected to be very close to that of road gasoline (94c). The National Energy Program projection gave 79c for gasoline and 76c for diesel, also very close. The result seems fairly reasonable, as the prices of the two have moved together in recent years. The demand for road diesel during the 1980s will likely increase rapidly, with continued dieselization in trucking and bus and some switch to diesel cars. There is a debate as to whether limited supply will put additional pressure on prices. Demand for road diesel rose 16% in 1979 and about 10% in 1980, while demand for rail and marine diesel stayed almost flat. Road diesel is still less than half of the diesel consumed in transportation, however, and with the coming on stream of upgrading plants in the Western region plus some "give" in rail and marine demand (both can with some adjustment, burn the cheaper bunker fuels) it is not certain that supplies for road will be under heavy pressure.

3.4 Rail Diesel

The method here diverges considerably from that of EMR, whose historical price proxy was apparently derived from list prices for diesel. According to Imperial Oil, however, the discounts in diesel for the railways, who are big customers, are considerable. In latter years they range from 1c/litre to 4c/litre (4% to 25%) at the higher end when supplies are more plentiful. Since the oil companies consider "realized" prices a confidential matter, the best source available for actual prices paid by the railroads is perhaps Statistics Canada, which collects information on total

TABLE 8

PROVINCIAL GASOLINE PRICES AND AD VALOREM TAX RATES
July, 1981

	Average: Regular Leaded and Unleaded, ¢/litre	Ad Valorem Provincial Road Taxes
Newfoundland	42.3	22%
Prince Edward Island	42.5	22%
Nova Scotia	37.9	(1)
New Brunswick	37.7	16%
Quebec	39.0	20%(2)
Ontario	38.8	20%
Manitoba	37.1	20%
Saskatchewan	38.2	20%
Alberta	29.8	-
British Columbia	37.4	20%

(1) Nova Scotia's road tax is still fixed at 4.7¢/litre.
(2) Increased to 40% in November, 1981.

TABLE 9

UNIT PRICES FOR RAIL DIESEL AND AVIATION TURBO, CANADIAN COMPANIES, 1971-1979

	Rail Diesel (1)	Aviation Turbo (2)	Ratio (2) : (1)
1971	15.02	18.69	1.244
1972	16.20	18.24	1.126
1973	18.23	21.11	1.158
1974	28.78	34.86	1.211
1975	34.14	43.31	1.269
1976	38.46	47.85	1.244
1977	43.86	54.06	1.233
1978	50.42	60.10	1.192
1979	56.47	71.04	1.258

Source: Statistics Canada, 52-208, 51-002 quantities and values of different fuels consumed by Canadian railroads.

Energy, Mines and Resources apparently chose to project future prices on the basis of a 1.33 ratio for diesel price increase to crude oil price increase. This appears to have been the case over 1979-80. Using it for future price increases seems somewhat arbitrary, however, and result in a forecast of 291% growth in the price of rail diesel as compared to 227% and 234% in motor gasoline and road diesel.

Forecasts in the present study used a simplified version of the approach taken for motor gasoline and road diesel. Thus, a current refiner's operating cost plus profit margin is derived and inflated at the CPI rate. Also incorporated is a 9% federal sales tax. Most provinces do not tax fuels used in locomotives, and railways tend to buy their fuel direct from refineries, eliminating retail margins.

The second scenario for rail diesel prices gives a lower (64c/litre) price in 1990 than the original National Energy Program, which is not true for any other fuel price. The difference comes from the assumption as to how the refineries will pass on price increases in crude oil. The NEP projection implicitly assumes that the refinery margin will be around 28% of the value of crude oil in 1990, whereas this study's method puts it at about 17% of the crude oil value in the optimistic case.

TABLE 10

PRICES OF DIESEL AND CRUDE OILS IN RAIL AND MARINE, CANADIAN COMPANIES, 1971-1979

(¢/gallon)

	Diesel			Crude Oils			Crude Oil
	Rail	Marine	Ratio	Rail	Marine	Ratio	Price to Refinery
1971	15.02	16.73	1.114	9.78	9.26	.947	-
1972	16.20	17.51	1.081	12.39	11.40	.920	-
1973	18.23	20.48	1.123	13.48	12.04	.893	-
1974	28.78	n.a.	-	21.65	n.a.	-	-
1975	34.14	n.a.	-	27.25	n.a.	-	-
1976	38.46	42.46	1.104	31.70	25.85	.815	26.70
1977	43.86	44.99	1.026	37.15	31.18	.839	31.76
1978	50.42	51.07	1.013	43.59	43.67	1.002	37.91
1979	56.47	59.49	1.053	49.66	48.03	.967	42.08

Sources: Statistics Canada for rail and marine prices. Energy, Mines and Resources for crude oil price.

3.5 Aviation Turbo and Gasoline

Energy, Mines and Resources used off-road (rail) diesel as a proxy for the value of aviation turbo. Again, Statistics Canada series on the realized values of each are available (see Table 9).

Since 1971, the value of aviation turbo has been about 1.2 that of rail diesel, which makes the EMR approximation seem reasonable. Accordingly, turbo prices have been projected as being above the price of rail diesel by the 1971-79 average.

Aviation gasoline prices were not forecast by EMR. This product has slightly different specifications from motor gasoline. A series on realized retail prices from Statistics Canada was compared to a refinery gate price series inclusive of federal sales tax, obtained from EMR (via the Air Administration). The apparent refinery margins were higher than those seen for motor gasoline whereas retail margins appeared lower. Dealers at the airport now pay 7c/gallon federal fuel concession tax and provincial sales tax of about 5%-8%. Forecasts of prices were made using the two-margin method as in motor gasoline. The projected price in 1990, 92¢ in the second scenario, is just slightly below the price for motor gasoline (94¢).

3.6 Marine Fuels

Marine diesel and bunker prices were projected by EMR on the price of off-road diesel. For the purposes of this study, marine diesel after 1981 is sold at 1.073 times the rail diesel prices already projected. This is the average ratio observed between 1971 and 1979 in Statistics Canada series on marine and rail diesel. Marine bunker prices are set at 1.061 times the price of crude oil to refineries, which is a four-year average of the ratios between 1976 and 1979 (see Table 10). The latter method is admittedly arbitrary, but can be defended because bunkers are more or less a by-product of the production of other fuels, and have consistently been plentiful during the last several years.

Statistics Canada series show that, domestically, prices for heavy fuel oils in marine seem to follow those in rail. Diesel prices are also similar to those in rail. The quantity sold peaked in the early 1970s, but has seemed fairly stable since, with foreign companies buying roughly 25% of the total diesel and 60% of the bunker (1978 ratios). Obviously, the price faced by foreign companies will heavily influence total demand. There is little information available before 1980 on prices paid by foreign companies, but it seems clear that the oil companies were charging them a price corresponding to the local American price while domestic companies paid considerably less. In Eastern Canada, where refineries are subsidized to buy oil at the international price for crude, this seemed a legitimate pricing decision. In Ontario and Western Canada, however, the refineries bought domestic crude at lower domestic rates and the price differential represented a windfall to the oil companies. In recent years with the rapid rise in international prices, this differential became very large.

In 1980, the National Energy Board was charged with recovering the import compensation for the Government of Canada by extending the export tax ("export surcharge") to all oil used in international shipping, whether by Canadian or foreign-owned companies. In the East, this tax is paid by the refinery, and in the West, by the shipping company. The amount of the tax is a function of the local international price of crude: West Coast, East Coast, Great Lakes.

Since the imposition of the export charge in 1980, the oil companies have raised their prices to domestic companies, even for oil for domestic use. Whereas prices to foreign companies cannot realistically be raised above the international level, without loss of sales, raising the domestic price is the best way for the oil company to recover the profit lost after the tax was imposed.

There is now extra pressure on fuel prices paid by domestic shipping. The basic crude oil price will rise quickly, and a particular pricing strategy that might have helped keep domestic prices lower has apparently been changed. The effect by 1990, when the import compensation has been reduced from $20 in 1980 to $7 - $9 (nominal), will likely eliminate any domestic and foreign marine fuel price differential. Acting against a rapid price rise in bunker will be the persistent plentiful world and domestic supply. There are indications (1976, 1977) that refineries sometimes take a loss on bunker, which is more or less a by-product of operations to obtain higher-grade fuels. The net effect of these factors is impossible to determine at this point, and the price series on marine bunker and diesel fuel have therefore been set according to historical relationships.

4. OPERATING COSTS BY MODE

4.1 Historical, 1976-1980

4.1.1 General

Sources used were Statistics Canada reports for the total industry, except in rail, where CN was used as a proxy for passenger rail and CP as a proxy for rail freight. The aim of the exercise was to determine what percentage of operating costs has been represented by fuel costs, compared with other major expense items (e.g.. labour, depreciation), and to "track" recent increases in energy prices in terms of the rising percentage of costs represented by fuel (see Table 11). The historical information was used as background for the projection of operating costs to 1990, described in Section 4.2 below.

TABLE 11

FUEL COSTS AS PERCENTAGE OF OPERATING COSTS, BY MODE, 1976-80
(%)

Mode	1976	1977	1978	1979	1980
Air	19.3	19.8	19.7	20.9	23.2
Intercity Bus	7.4	7.3	7.3	7.3	n.a.
Rail					
CN	5.9	6.5	7.0	7.2	8.4
CP	6.6	7.2	7.7	8.1	9.5
For-Hire Trucking	9.1	9.3	9.1	9.5	10.2
Marine	9.2	9.5	9.9	11.4	n.a.
Urban Transit	5.3	5.1	5.3	5.2	n.a.

Source: Statistics Canada

TABLE 12

HISTORICAL OPERATING COSTS - AIR

	1976	%	1977	%	1978	%	1979	%	1980	%
Total ($m)	1,642.1	100.0	1,789.2	100.0	2,017.0	100.0	2,419.8	100.0	2,990.0	100.0
Salaries, wages and personal expenses	622.2	37.9	681.2	38.1	712.0	35.3	862.4	35.6	1,049.9	35.1
'Employee welfare' (UI, pensions, insurance plans)	45.8	2.8	55.0	3.1	89.7	4.4	94.2	3.9	98.5	3.3
Materials and supplies	443.9	27.0	483.0	27.0	555.5	27.5	708.9	29.3	893.3	29.9
(Aircraft fuels and oils only)	(317.1)	(19.3)	(353.6)	(19.8)	(397.8)	(19.7)	(505.1)	(20.9)	(694.5)	(23.2)
Other expenses ex. 'employee welfare', totalled:	378.6	23.1	419.7	23.5	510.1	25.3	594.1	24.6	759.1	25.4
(Traffic commissions)	(68.2)	(4.2)	(83.1)	(4.6)	(104.2)	(5.2)	(130.8)	(5.4)	(160.7)	(5.4)
(Repairs & other services outside)	(75.3)	(4.6)	(87.5)	(4.9)	(108.7)	(5.4)	(129.3)	(5.3)	(205.4)	(6.9)
(Landing fees)	(43.4)	(2.6)	(45.5)	(2.5)	(53.5)	(2.7)	(68.6)	(2.8)	(66.2)	(2.2)
Depreciation and Amortization	151.6	9.2	150.3	8.4	149.7	7.4	160.2	6.6	189.2	6.3

Source: Statistics Canada # 51-206.

4.1.2 Passenger Modes

a. Air

For domestic air carriers, 35% of costs incurred are now labour-related. Another 30% are for materials and supplies, of which 23% is for fuel and oil. The remaining 35% includes traffic commissions, landing fees, depreciation and amortization (see Table 12).

Between 1976 and 1980, total operating costs for domestic carriers rose 82% in current dollars. Aircraft fuel and oil expenses, meanwhile, rose 119%. (The average price paid for turbo fuel went from 48c/gal to 90¢/gal). Salaries, wages and employee welfare rose 72%, and materials and supplies 101%. Depreciation and amortization rose by only 25%. As a result of these differing rates of increase, the relative importance of cost components has changed, with fuel rising to 23.2% of total costs in 1980 versus 19.3% in 1976; and materials and supplies, 29.9% versus 27%. Labour expenses declined from 40.7% of the total operating expenses to 38.4%, and depreciation declined from 9.2% to 6.3%.

b. Rail

It was decided to proxy rail passenger operating costs over 1976-1980 with those of CN, because a breakdown of VIA costs was not forthcoming and expenses for passenger rail, as reported, are not separable from those for rail freight. The picture given will be somewhat misleading, however, because CN still carries more freight traffic than it does passenger traffic. Nevertheless, it does account for about 15% of rail passenger mileage, so a look at its costs is instructive.

More than half of all operating expenses (54% in 1980) of CN are for salaries, wages and pensions (see Table 13). Locomotive fuel and power represents only 8.4% of the total, and depreciation (stock plus roadway) another 5.2%. Over 1976-80, total expenses rose 46%, with the fastest-growing cost components being fuel and power (107% increase) and tax accruals (68% increase). Labour costs (including pensions) rose by only 38%. The result has been, as in air, a decline in labour costs as a percentage of the total, from 57% to 54%, and an increase in the fuel expense share, from 5.9% to 8.4%.

TABLE 13
HISTORICAL OPERATING COSTS - PASSENGER RAIL

(Proxy: Canadian National)

	1976		1977		1978		1979		1980	
	($000)	%	($000)	%	($000)	%	($000)	%	($000)	%
Total (ex express, highway transport, telecommunications and outside operations)	1,682,953	100.0	1,795,062	100.0	1,977,266	100.0	2,193,043	100.0	2,461,006	100.0
Salaries + Wages[1]	848,644	50.4	883,597	49.2	950,563	48.1	1,054,894	48.1	1,168,446	47.5
Pensions[2]	118,601	7.0	119,694	6.7	144,013	7.3	165,054	7.5	156,741	6.4
Total	967,245	57.4	1,003,291	55.9	1,094,576	55.4	1,219,948	55.6	1,325,187	53.8
Locomotive fuel + power	99,568	5.9	117,125	6.5	137,844	7.0	157,548	7.2	205,969	8.4
Rolling stock + vessels, depreciation.	50,949	3.0	53,314	3.0	48,150	2.4	50,229	2.3	49,505	2.0
Roadway property, depreciation	60,498	3.6	64,612	3.6	66,819	3.4	74,863	3.4	78,500	3.2
Equipment + joint facility rentals	57,004	3.4	49,433	2.8	50,030	2.5	56,170	2.6	77,702	3.2
Railway tax accruals	67,432	4.0	76,505	4.3	86,576	4.4	101,964	4.6	113,455	4.6
sub-total	1,302,696	77.4	1,364,280	76.0	1,483,995	75.1	1,660,722	75.7	1,850,318	75.2
residual	380,257	22.6	430,782	24.0	493,271	24.9	532,321	24.3	610,688	24.8

1. Adjusted to reflect exclusion of express, etc..
2. Figure in 52-208 already refers to railway operations only. (C.N.)

Sources: 52-212, 52-208.

TABLE 14

HISTORICAL OPERATING COSTS - INTERCITY BUS

	1976				1977			
	All Classes	Class 1 & 2	%		All Classes	Class 1 & 2	%	
Total Operating Costs ($000)	172,985	168,048	100.0	100.0	200,832	194,060	100.0	100.0
Salaries plus UI, pensions and other employee benefits	87,987	85,924	50.9	51.1	101,144	98,437	50.4	50.6
Fuel plus taxes on fuel	12,754	11,966	7.4	7.1	14,738	13,824	7.3	7.1
Tires, tubes, vehicle parts		9,491		5.6		10,940		5.6
Leases, rentals, purchased transportation		4,767		2.8		5,184		2.7
Depreciation (all vehicles, equipment & buildings)		6,895		4.1		7,799		4.0
Residual items		49,005		29.3		58,076		30.0
Fuel excluding taxes		n.a.				9,577		
	1978				1979			
Total Operating Costs ($000)	211,668	206,921	100.0	100.0	224,138	219,571	100.0	100.0
Salaries plus UI, pensions and other employee benefits	108,350	106,493	51.2	51.5	119,347	117,772	53.2	52.5
Fuel plus taxes on fuel	15,477	14,761	7.3	7.1	16,354	15,583	7.3	7.1
Tires, tubes, vehicle parts		16,274		7.9		15,988		7.3
Leases, rentals, purchased transportation		6,750		3.3		7,108		3.2
Depreciation (all vehicles, equipment & buildings)		9,871		4.8		7,698		3.5
Residual items		52,772	41.5	25.4		55,422	39.5	25.2
Fuel excluding taxes		10,558				11,644		

Source: SC 53-215

c. Intercity Bus

Statistics were only available to 1979 for the industry, but these show that the cost structure is basically similar to that of rail: more than half the expenses incurred are labour-related, fuel costs (in 1980) were 7.4% of the total, and depreciation was 3.5% (see Table 14).

Changes since 1976 in the cost structure, however, have differed from that of rail. Over the period, total costs rose at an annual rate of 9%, labour costs rising at 11% annually, because of high wage settlements, and fuel costs rose at about 9% annually. (Over the same period, by comparison, CN's total operating expenses also rose by 9% annually, but labour costs grew by 8% and fuel costs by 17% annually.) Thus, over 1976-79, the labour component of operating costs rose from 50.9% of the total to 53.2%, while the fuel component remained relatively constant: 7.4% in 1976, 7.3% in 1979. The implication is that, at least until 1979, intercity bus was managing to keep fuel cost increases in line with other cost increases.

d. Urban Transit

Once again, statistics were only available to 1979. In that year, salaries, wages, unemployment, pensions and other employee benefits made up 73% of all operating costs (see Table 15). Fuel was only 5% of the total, and depreciation another 2%.

Over 1976-79, increases in the various major cost components were about the same: 10-11% annually, so that there were no real shifts in the importance of various cost components. This implies that fuel cost increases were being kept in line with other cost increases.

4.1.3 Freight Modes

a. Rail

CP was chosen to represent the typical freight railroad, since it does carry a large share of the country's freight traffic. The basic picture is similar to that for CN. In 1980, labour costs (salaries and wages plus pensions) were 46% of total operating costs, locomotive fuel and power was about 10%, and depreciation (stock plus roadway) about 5% (see Table 16).

Over 1976-80, total operating costs went up by 53%, with labour costs rising by 35%, fuel by 118%, and taxes by 97%. The net result has been a decline in the labour component (from 51.8% of total costs to 45.9%) and rises in the fuel component (from 5.6% to 9.5%) and in the tax component (from 8.8% to 11.3%)

b. For-Hire Trucking

In 1980, labour costs (salaries and unemployment insurance, pensions and other benefits) were 46% of all operating costs for the total of motor carriers and household goods movers (see Table 17). Fuel formed another 10% of total operating costs, and the larger residual items were piggyback, interline and rental payments (7%) and depreciation (7%).

Over 1976-80, total costs grew at an average annual rate of 15%, with labour-related costs growing at 14% and fuel costs at 18%. The piggyback, interline and rental component, however, increased at 13% per year. The net result was a slight decrease in the percentage of total costs incurred for labour, and an increase in the percentage incurred for fuel and piggyback, interline and rental expenses.

The road modes--urban transit, bus and trucking--have recently seemed best able to "contain" energy cost increases.

c. Marine

Statistics were only available to 1979 for the industry. In that year, 40% of marine operating costs were for salaries and unemployment insurance, pensions and employee benefits (see Table 18). Fuel was another 11% of operating costs, and depreciation another 6%. The larger residual expense items were purchased transport: (17%) and maintenance and repairs (9%).

More detailed comparisons over 1976-79 are probably misleading because of the irregularity in some cost components, which were due to variations in the sample of companies. There has, however, been a fairly steady rise in the fuel percentage of operating costs, averaging 12% per year.

TABLE 15

HISTORICAL OPERATING COSTS - URBAN TRANSIT

	1976				1977			
	All Classes	Class 1 & 2	%		All Classes	Class 1 & 2	%	
Total Operating Costs ($000)	649,020	633,384	100.0	100.0	720,330	714,376	100.0	100.0
Salaries + UI, Pensions and Other Employee Benefits	470,809	461,317	72.5	72.8	533,083	529,623	74.0	74.1
Fuel + taxes on fuel	34,223	32,820	5.3	5.2	37,037	36,462	5.1	5.1
Tires, tubes, vehicle parts	21,635	21,513	3.3	3.4	27,390	27,349	3.8	3.8
Leases, rentals purchased transportation	8,496	8,225	1.3	1.3	10,887	10,587	1.5	1.5
Depreciation (all vehicles, equipment and buildings)	23,012	22,648	3.5	3.6	18,724	18,618	2.6	2.6
Residual Items	90,845	86,861	14.0	13.7	93,209	91,737	12.9	12.8
	1978				1979			
Total Operating Costs ($000)	809,816	806,470	100.0	100.0	879,754	876,578	100.0	100.0
Salaries + UI, Pensions and Other Employee Benefits	600,926	597,834	74.2	74.1	642,628	640,778	73.0	73.1
Fuel + taxes on fuel	42,752	42,333	5.3	5.2	45,922	45,573	5.2	5.2
Tires, tubes, vehicle parts	32,156	32,108	4.0	4.0	37,879	37,827	4.3	4.3
Leases, rentals purchased transportation	12,669	12,462	1.6	1.5	14,705	14,628	1.7	1.7
Depreciation (all vehicles, equipment and buildings)	15,682	15,580	1.9	1.9	15,700	15,628	1.8	1.8
Residual Items	105,631	106,153	13.0	13.2	122,920	122,144	14.0	13.9

Source: 53-215.

TABLE 16

HISTORICAL OPERATING COSTS - RAIL FREIGHT
($000)

(Proxy: Canadian Pacific)

	1976	%	1977	%	1978	%	1979	%	1980	%
Total (Ex. Commercial Communications)	1,060,896	100.0	1,179,242	100.0	1,302,094	100.0	1,456,066	100.0	1,619,299	100.0
Salaries + Wages*	476,824	44.9	518,048	43.9	556,453	42.7	614,722	42.2	653,064	40.3
Pensions	72,401	6.8	75,389	6.4	86,523	6.6	88,863	6.1	90,656	5.6
Total	549,225	51.8	593,437	50.3	642,976	49.4	703,585	48.3	743,720	45.9
Locomotive Fuel + Power	70,249	6.6	84,345	7.2	100,833	7.7	118,402	8.1	153,418	9.5
Depreciation:										
Rolling stock	39,961	3.8	40,316	3.4	40,149	3.1	39,468	2.7	40,586	2.5
Roadway	34,218	3.2	35,711	3.0	37,786	2.9	40,590	2.8	43,339	2.7
Equipment and Joint Facility Rentals	23,501	2.2	21,125	1.8	17,952	1.4	31,804	2.2	39,702	2.5
Railway Tax Accruals	93,099	8.8	104,437	8.9	119,918	9.2	140.531	9.7	183,333	11.3
Residual Items	250,643	23.6	299,871	25.4	342,480	26.3	381,686	26.2	415,201	25.6

Source: 52-208, 52-212, C.P.

* Adjusted to exclude commercial communications, by ratio of the latter to total.

TABLE 17

HISTORICAL OPERATING COSTS - FOR-HIRE TRUCKING*

($000)

	1976				1977				1978			
	Total	Motor Carriers	% Total	% Motor Carriers	Total	Motor Carriers	% Total	% Total Carriers	Total	Motor Carriers	% Total	% Motor Carriers
Total Operating Costs ($000)	2,579,345	2,407,463	100.0	100.0	2,926,282	2,714,776	100.0	100.0	3,570,361	3,324,394	100.0	100.0
Salaries - UI, Pensions and Other Employee Benefits	1,259,962	1,178,574	48.8	49.0	1,412,505	1,303,758	48.3	48.0	1,722,894	1,596,541	48.3	48.0
Fuel - taxes on fuel	235,609	227,163	9.1	9.4	273,029	262,579	9.3	9.7	325,666	313,677	9.1	9.4
Tires, tubes vehicle parts	52,080	50,482	2.0	2.1	60,935	59,150	2.1	2.2	68,870	66,880	1.9	2.0
Piggyback, interline, rentals	186,404	178,044	7.2	7.4	208,214	189,718	7.1	7.0	242,043	232,931	6.8	7.0
Depreciation (all vehicles, equipment and buildings)	179,209	154,818	6.9	6.4	196,787	172,631	6.7	6.3	242,775	231,154	6.8	7.0
Residual Items	666,081	618,382	26.0	25.7	774,812	726,940	26.5	26.8	968,113	883,211	27.1	26.6

	1979				1980			
	Total	Motor Carriers	% Total	% Motor Carriers	Total	Motor Carriers	% Total	% Motor Carriers
Total Operating Costs ($000)	4,025,247	3,781,335	100.0	100.0	4,547,015	4,258,584	100.0	100.0
Salaries - UI, Pensions and Other Employee Benefits	1,887,929	1,761,575	46.9	46.6	2,097,146	1,952,300	46.1	45.8
Fuel - taxes on fuel	382,109	370,120	9.5	9.8	464,521	449,529	10.2	10.6
Tires, tubes vehicle parts	81,056	79,066	2.0	2.1	96,110	93,539	2.1	2.2
Piggyback, interline, rentals	257,491	250,434	6.4	6.6	315,085	305,357	6.9	7.2
Depreciation (all vehicles, equipment and buildings)	287,143	275,522	7.1	7.3	334,181	320,073	7.3	7.5
Residual Items	1,129,519	1,044,618	28.1	27.6	1,239,972	1,137,786	27.4	26.7

* Totals for motor carriers and household goods movers, adjusted to exclude payments to brokers.

Source: Statistics Canada, 53-222

TABLE 18
HISTORICAL OPERATING COSTS - MARINE

	1976				1977			
	All Classes	For Hire	%		All Classes	For Hire	%	
Total Operating Costs* ($000)	1,595,256	845,043	100.0	100.0	1,845,023	916,386	100.0	100.0
Salaries + UI, Pensions and Employee Benefits	529,711	277,208	33.2	32.8	699,938	298;169	37.9	32.5
Fuel + taxes on fuel	146,044	98,071	9.2	11.6	174,825	116,872	9.5	12.8
Maintenance & Repairs	123,746	69,255	7.8	8.2	134,006	72,241	7.3	7.9
Purchased Transport	351,843	152,905	22.1	18.1	321,404	171,196	17.4	18.7
Depreciation (all vehicles, equipment and buildings)	68,379	48,939	4.3	5.8	90,150	53,570	4.9	5.8
Residual Items	375,533	198,665	23.5	23.5	424,700	204,338	23.0	22.3
Fuel (ex. taxes)	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	1978				1979			
Total Operating Costs* ($000)	1,941,760	1,025,366	100.0	100.0	1,831,282	966,062	100.0	100.0
Salaries + UI, Pensions and Employee Benefits	725,636	324,518	37.4	31.6	733,403	312,023	40.0	32.3
Fuel + taxes on fuel	192,657	130,797	9.9	12.8	208,537	136,012	11.4	14.1
Maintenance & Repairs	137,936	82,725	7.1	8.1	161,124	95,756	8.8	9.9
Purchased Transport	375,585	187,127	19.3	18.2	304,390	136,091	16.6	14.1
Depreciation (all vehicles, equipment and buildings)	104,091	63,201	5.4	6.2	106,906	102,909	5.8	10.7
Residual Items	405,855	236,998	20.9	23.1	316,922	183,271	17.3	19.0
Fuel (ex. taxes)	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

* Exclusive of 'non-transportation' activities, e.g. - hotels, etc.

Source: Statistics Canada # 54-205.

4.2 Forecasts, 1980-1990

4.2.1 General

Base-year cost breakdowns are provided in Section 4.1. To generate projections to 1990, each cost component was examined individually and forecast separately. The forecast total cost by mode is the sum of the forecast components. (Passenger modal cost/fare forecasts are contained in Table 22.) In this way, forecasts of the dollar cost of each component include factor quantity substitution effects which occur in response to factor price changes, innovations and technology. Further analysis of these effects using modal cost functions is planned.

Highlights of the forecasts for cost components by mode are presented here with emphasis on fuel costs. Table 20 illustrates the significance of fuel costs by mode for each of the two energy price scenarios used in this study. Forecasting operating costs is a hazardous exercise, especially for components such as depreciation. The objective here was consistency across modes in the assumptions used.

4.2.2 Intercity Bus

Drivers' wages were assumed not to keep pace with inflation to 1985, but match inflation thereafter. This is one of several assumptions taken from a presentation to the 1981 annual meeting of the Ontario Motor Coach Association. The argument is that, in the short term, wage and salary increases will be a target in the Government's fight against inflation, and that companies will not be able to afford labour cost increases of the order experienced recently. The November 12, 1981, budget projected a slight decrease in real average wages for the economy from 1981 to 1985.

Another assumption here is that depreciation costs will increase slightly below inflation, based on projected bus price increases and a 12-year replacement rate in the fleet. Because of an expected increase in the supply of new vehicles, price increase for new vehicles are expected to increase below the rate of inflation.

An immediate 15% correction for low current insurance rates was incorporated. Significant increases in finance charges were assumed throughout the forecast period because of an expected continuation of high interest rates. Another cost component showing rapid growth is repair parts which grew at 3.5% above inflation in 1980 and 2.5% in 1981, reflecting a weakening Canadian dollar and rising oil prices (affecting the production of tires, for example).

Fuel costs were projected on the basis of forecast road diesel prices for the two scenarios. The NEP/Agreement scenario assumed world crude oil prices and, secondly, what is considered to be more likely increases in world prices. Thus, as in Table 20, fuel costs are expected to increase to between 13-15% of total operating costs in 1985 from 7% in 1979, and to 15-18% in 1990.

4.2.3 Rail Passenger

It proved impossible to project operating costs for passenger rail by item as was done for other modes. The largest percentage of mileage in rail is reported by VIA Rail (68% with CN accounting for another 15%), but the present uniform system of accounting used for VIA Rail and the two railways that run its services is outdated and under revision. A breakdown of VIA's expenditures by item is not available, and will not be so until the accounting system is revised.

There is some justification for considering the energy price effect upon total operating costs to be less crucial for this mode than for the others, at least in the context of a demand-oriented study. Given the high deficits already existing in rail passenger carriage, energy price increases are not likely to be completely reflected in fares, which are the final determinant of demand. In general, fares in passenger rail have followed those in the bus industry, and this is how they were projected in this study.

4.2.4 Air

Although wage and salary costs grew significantly in 1979 and 1980, it was assumed that to 1985 this cost component would increase at approximately 1% below inflation, the same as for bus. Depreciation costs were assumed to return to the 1976 level by 1985, following the introduction of new aircraft, while other costs were assumed to grow at the rate of inflation, with the exception of fuel.

Jet fuel price increases of 10.4% and 7.3% a year in constant dollars are projected for the two scenarios from 1981 to 1985, following a real price increase of 18.9% in 1981. Combined with slow traffic growth and fuel efficiency improvements, the result is fuel costs of between 30-33% of total operating costs in 1985. With fuel prices expected to increase by 3.1% or 0.6% in real terms from 1985 to 1990, fuel costs by 1990 would range from 31-35% of the total.

4.2.5 Automobile

Before projecting automobile operating costs, it was necessary to estimate a base-year breakdown. This is presented in Table 19, along with projections to 1990 under Scenario I. In 1980, it was estimated that variable costs accounted for 37% of total operating costs with fuel representing close to 25%. Depreciation costs were based on 15% of average auto prices.

For the projections, average auto prices were expected to increase at about 1% below inflation to 1985, and remain constant in real terms from 1985 to 1990. Insurance and license fees were assumed to be below normal at present (as for bus) and increase at the rate of inflation following an immediate 15% adjustment. There would be a slight decrease to 1985 in average kilometres driven per vehicle but a return to current levels by 1990. Also, in Table 19, a constant fleet size was assumed.

As a result of these projections, fuel costs in 1985 were expected to range from 28.3% of total costs for the lower fuel price scenario to 31.5% for the NEP/Agreement. By 1990, as a result primarily of continued efficiency improvements, fuel costs may range from 25.7% to 29.7%.

TABLE 19

AUTOMOBILE OPERATING COSTS, 1980-90, SCENARIO I (CONSTANT 1980 DOLLARS)

		1980	1985	1990
Fixed Costs per Vehicle				
Depreciation		1160	1100	1100
Insurance and License		400	460	460
Variable Costs per Vehicle				
Gasoline	(c/litre)	24.5	42.2	47.2
	(litres/100 km)	16.0	13.5	10.8
	(c/100 km)	392	570	510
Maintenance	(c/100 km)	194	200	210
(Average Kilometres)		15,500	15,000	15,500
Total Variable Costs		908	1,150	1,100
No. of Vehicles (million)		10	10	10
Fleet Operating Costs ($ billion)		24.7	27.1	26.8

4.2.6 For-Hire Trucking

For the public passenger modes described above, it was assumed that labour costs would not match the rate of inflation in the short term. This is consistent with expectations for the economy in general. Certain sectors, however, will be affected by shortages of skilled labour, to the extent that real wages in those sectors will increase. This is assumed to hold in for-hire trucking, where both drivers and mechanics must cope with the new generation of trucks, with electrical/mechanical systems and complex engine technology, and where traditional sources of labour (young males off farms) have dried up.

Other assumptions include repair parts costs increasing at the inflation rate, as higher costs are offset by more "cannibalization" of parts from unused machines. Increased real costs for leases and rentals are assumed as trucking companies get into this field to offset competition from private carriers. Finally, depreciation costs are assumed to grow on average at 1% below inflation in the short term until sales of new vehicles recover.

As a result of these assumptions, together with expected increases in the price of road diesel of 75% or more than 91% in constant dollars from 1979 to 1985 for the two scenarios, fuel costs increase from 9.5% of the total in the base year to between 15-16%. By 1990, fuel costs are not expected to become much more significant, at 14-17% of all operating costs, reflecting further efficiency improvements and slower growth in fuel prices.

4.2.7 Rail Freight

Labour shortages are not expected to be as severe as in trucking (a current surplus exists as a result of the passenger service cutbacks), and wages and salaries will increase at the rate of inflation. Rapid increases in depreciation costs are anticipated, conservatively estimated at 2% above inflation on average, as a result of the capital expansion programs of CN and CP. Equipment and joint facility rentals are assumed to grow at 1% above inflation, as for buses, while tax accruals will match inflation.

Fuel costs for rail freight traffic are expected to represent more of a burden in terms of total costs than for trucking, accounting for between 15-17% of all operating costs in 1985 and 16-19% in 1990.

4.2.8 Marine

Labour costs, representing a third of total operating costs for this mode, have been increasing, and a continued slight increase in real terms is assumed as a result of shortages. Off-shore oil development and expansion of Arctic shipping, for example, may put pressure on salaries and wages.

Fuel costs for marine are expected to account for 17-19% of all operating costs in 1985, compared with 11% in 1979. By 1990, they may reach 18-21% (see Table 20).

TABLE 20

FUEL COSTS AS PERCENTAGE OF OPERATING COST, BY MODE AND SCENARIO (1)
1979-90

Mode	1979 (2)	1985		1990	
		I	II	I	II
Air	20.9	32.6	30.4	35.0	31.0
Intercity Bus	7.3	14.8	13.5	17.6	14.6
Rail Freight	8.1	16.7	15.2	18.8	15.5
For-Hire Trucking	9.5	15.9	14.8	16.9	14.3
Marine	11.4	19.3	17.6	21.4	17.7
Auto (3)	24.7	31.5	28.3	29.7	25.7

(1) Scenario I is the NEP/Agreement, Scenario II includes lower energy prices
(2) Data unavailable for all modes for 1980.
(3) Estimated for the base year.

5. TECHNOLOGICAL PROGRESS - TRENDS AND PROJECTIONS

5.1 General

This section describes probable fuel efficiency improvement in transportation by 1990. The figures produced are a blend of information from a variety of sources, and are only general estimates. Further efforts are required to develop wider sources of information on changes in the fleet by mode. In addition, a method of incorporating such information in an acceptable framework designed to quantify the effect on fuel efficiency is required. In the meantime, this study presents brief highlights of likely changes, resulting from discussions with various people and from a cursory look at current literature. The percentage changes used represent the most accurate assessment of opinion within Transport Canada's Strategic Planning Group.

To quantify fuel efficiency improvement in a mode, information is required on changes in miles per gallon achieved by vehicles, on the speed and manner by which technology is introduced to the fleet, on load factors and on vehicle use. Such factors vary over portions of the transportation system, whereas the concern here is with the total national system. Thus, the estimates in Table 21 conceal a wide range of fuel efficiencies for each mode and are not intended for intermodal comparisons over specific parts of the system, but rather to show potential improvements by mode to 1990.

5.2 Air

As fuel costs have become an increasingly larger portion of operating costs, much has been done to improve fuel consumption characteristics in air. Some scope still exists for technological advance, aside from the introduction to the fleet of more fuel-efficient aircraft. For example, a 15% fuel economy may be obtained from re-engining DC8s, and "internal modifications" to the engines of 727s (C. Glenn, Air Canada) are also possible in the interests of fuel economy. In the longer term (beyond 1990), computer-enhanced microwave landing systems as an adjunct to current air traffic control will allow parallel runways to be used, thereby reducing airport congestion and "stacking". This will result in major fuel conservation.

Operationally, further increases to load factors through changes in seating density will provide minimal improvements. More will be

TABLE 21

FUEL INTENSITY ESTIMATES TO 1990

PASSENGER MODE		GALLONS/THOUSAND PASSENGER-MILES			
		1976	1979	1985	1990
Air		36.1	32.6	30.0	29.0
Rail		26.9	25.8	21.7	20.7
Bus	Intercity	4.7	4.7	4.5	4.3
	Urban	7.7	7.7	7.3	6.9
Auto	Total	47.6	45.7	37.0	29.3
	Intercity	29.1	23.2	18.8	14.8
	Urban	65.8	52.4	42.4	33.6
FREIGHT MODE		GALLONS/THOUSAND TON-MILES			
Rail		3.6	3.5	3.3	3.1
Truck		15.3	14.2	13.1	12.3
Marine		2.3	2.3	2.2	2.2

accomplished by reductions in service frequency. Furthermore, current efforts to reduce fuel use by straight-in landing approaches, reductions in airspeed and better scheduling of take-offs and landings will continue.

In total, these measures should improve fuel use per passenger-kilometre by about 10-18%, more likely at the lower end of this range.

5.3 Bus

Relatively few technological advances are expected for the passenger bus fleet to 1990. Some fuel savings are expected from weight reductions (for example, using acrylic rather than glass in windows). There is also some scope for improved aerodynamics. The most substantial technological advance, however, will be the use of articulated buses in intercity service. These vehicles, with 40% greater seating capacity, should form 10% of the fleet by 1990. The effect on fuel use will come through passenger-kilometre fuel consumption, as vehicle fuel use is equivalent to conventional buses.

Voyageur Colonial reports innovations in the fuel monitoring field. Voyageur intends to augment its automatic speed governors with speed recorders operating with the vehicle's clock. In addition, a fuel consumption metering device is to be used, which will provide a continuous read-out on the dash-board. These three devices will be used to supplement planned driver training and more stringent driver selection.

Several operational initiatives will help to improve fuel consumption. Foremost is better vehicle maintenance with more frequent tune-ups, closer monitoring of tire pressures, etc. Reduced service frequencies are also under consideration, in anticipation of further improvements to passenger load factors. Also, depending on service level requirements, fleet size will be permitted to decline through attrition (possibly by 10%), leaving a younger, more fuel-efficient fleet.

In total, these changes are expected to reduce the amount of fuel use by 10% (Voyageur's target is twice this), with most changes occurring well before 1990.

5.4 Automobile

From now until 1990 no major switch from the internal combustion engine is foreseen for the passenger automobile. It is expected that the improvements of the late 1970s will be expanded to further reduce fuel consumption in existing vehicle types. These improvements include downsizing (accounting for 15% fuel savings by mid-1980s), more fuel-efficient and better-matched engines/drivetrains (14% by 1990), reduced air resistance via aerodynamics (2%), and more use of radial tires (2%).

In addition to these improvements to existing vehicles, design work is underway to eventually replace the internal combustion gasoline engine. One promising area of research is the electric vehicle. Vehicles produced now (including the commercially available Dodge electric van in Britain) are priced at approximately 25% above similar conventional vehicles. Such vehicles, with a battery service life comparable to conventionally-powered vehicles, have been in experimental use in Canada (e.g., at the Welland Canal) and are found to have fuel costs about one-tenth that of similar gasoline vehicles.

Operational changes to reduce congestion and improve traffic flow would improve auto fuel consumption, and rising real fuel costs will encourage the more efficient use of automobiles by reducing trip frequencies and lengths, and increasing the number of occupants per trip. The net result of all expected changes is a 30% (or greater) increase in automobile fleet efficiency.

5.5 Rail

Technical improvements to rail engines, such as better design, offer a potential reduction of 10% in fuel consumption. Fuel requirements could be reduced by a further 2% with modifications in the use of accessories, principally by changing to an "on-demand" fan. In addition, greater use in the passenger fleet of self-propelled rail diesel cars (RDCs), which normally operate in pairs of 86-seat cars, would save about 40% over conventional service on light-traffic routes.

Operationally, the practice of shutting down engines not in use, rather than idling them, would save the approximately 4 1/2 gallons of fuel used per hour of idle. If no more than half the engines were shut down, savings of more than 3% would result. Prospects for electrification are improved with escalating petroleum fuel costs, but this would have no effect on petroleum consumption until the 1990s. Reduction of grades would allow substantial saving. Currently, the Beaver Hill section requires 12 locomotives for a loaded train and a grade reduction of 1% would reduce this requirement to 5 locomotives. Less use of power braking (especially while under driving power) would greatly improve fuel performance. In sum, the introduction of the most likely changes will result in an 18% reduction in fuel consumption by 1990.

5.6 Marine

Owing to the prolonged life of marine vessels (more than 30 years for fresh-water craft) many technological advances are considered for "retro-fit" of existing equipment. With fuel costs representing a more significant portion of total operating costs, such retro-fitting is becoming more economically feasible.

The first and most obvious action is monitoring and performing engine/drive unit maintenance more rigorously. In the past, the expense (including time) required for such maintenance could not be justified by fuel savings. Similarly the cost of frequent cleaning of the hull and propeller (required more often for salt-water operation) could not be justified. But partly in response to increased fuel prices, new procedures and materials have become available for such cleaners. First, divers with mechanical cleaners are replacing the traditional time-consuming dry-dock approach. As well, new hull coatings and "slippery paints" have been developed to minimize fouling.

An auxiliary fuel demand after propulsion is "hotel" power (heating, lighting, etc). In this area, greater use could be made of exhaust heat recovery from propulsion units and more-efficient auxiliaries and peripheral devices. In some cases these changes require only relatively minor alteration to existing vessels. There is also the complementary concept of "shore connections" for operating power while at dock. This is now the practice in Canada's naval fleet and could easily be extended to the entire fleet.

Consideration is also being given to alternate fuels for marine vessels. Current gas-turbine engines (essentially an off-shoot of airline technology) that use relatively high-quality fuel can be converted to coal. The problem of course is that large amounts of coal are required with an accompanying loss in revenue-cargo capacity. Current diesel units are also being adjusted or modified to make use of the lower-quality heavy and light fuel oils expected in the late 1980s. Successful research has been done in the use of coal and oil "slurries" in existing diesel plants with no damage to the engines. The international fleet (specifically the Japanese and Americans) are reporting success in the use of computer-controlled sails to assist conventional craft, and use of these is conceivable in the Canadian fleet for some operations.

New vessels will likely make use of more streamlined hull designs. This brings a penalty in cargo capacity, but with current fuel costs the reduction can often be justified. This streamlining also includes the use of "bulbous" bows, which can be fitted on existing vessels, although this is rarely done at the present time. Replacement vessels (and existing vessels to a smaller extent) are making use of computer-controlled "controllable pitch" (C.P.) propellers. These optimize engine speed at any given vehicle velocity with allowance made for vibration.

Operationally, from current levels of service, each 1% reduction in speed gives a 2% reduction in fuel consumption. Thus "slow steaming" offers great scope for conservation, but at the price of service levels and with the shortened shipping season in the Great Lakes, there is the possibility of losing one or more trips. Advance warning of traffic congestion, especially in the Seaway, would allow ships' masters to reduce speed and therefore fuel use--a practice which is being implemented. Optimal use of meteorological information, allowing re-routing to avoid bad weather, will also reduce fuel use. By 1990, the net effect of these measures should be a 5% improvement in marine fuel consumption rates.

5.7 Truck

This sector has been relatively active in fuel conservation measures in the recent past. In the near future a further 18% improvement is probable, with most occurring by 1985. By 1990 most of the fleet will be diesel, reducing fuel consumption by about 7%. Switching to radial tires will offer an additional 7% improvement. Better matching of engines/drivetrains ("ground-up" design of newer units) will provide a 13% improvement, and reduction of air resistance another 4% (by the increased use of air deflectors). Driver training (as for bus, with governors and speed-recording devices) will likely account for a 5% improvement. All of these factors will apply in particular to larger fleet operations. Operations with fewer than five units will not be able to react as fast to technological change. In the longer term, radical changes to drivetrains will allow much lower fuel consumption. The use of different fuels (e.g., propane) will also reduce demand for gasoline and diesel.

6. TRANSPORTATION DEMAND FORECASTS

6.1 General

In this chapter, expected demand for transportation services in the 1980s is discussed. Inputs include macroeconomic indicators, fuel prices, operating costs and service level improvements. Existing intercity passenger and freight forecasting methods were used, and further information on these methods is available on request. For this study, the definition of intercity travel has been broadened to include all trips exceeding 50 miles.

For urban passenger travel, improved analytical techniques and data are required. Studies have been done on specific cities but little is available on total urban traffic. Similarly, there is a major deficiency in knowledge of urban freight or, more generally, all trucking except for-hire.

6.2 Intercity Passenger

6.2.1 Inputs and Methodology

The two energy price scenarios were used as the basis of two runs of the PERAM model, in which different costs to passengers as a result of oil prices were reflected.

In all scenarios the air mode experiences the most rapid escalation in costs (see Table 22). For example, air costs under Scenario I are forecast to increase about 1.9% annually in real terms to 1990 as compared to the automobile increase of less than 1.1% annually. Rail and bus costs, assumed to have identical rates of growth, increase 1.2% annually, a figure very similar to the automobile. According to Scenario II, the automobile cost increase to 1990 is very much less than either of the automobile increases in Scenario I or of the other modes in Scenario II. This figure for automobile costs shows a 0.4% annual rate of increase, as compared to 1% for air and over 0.8% for bus and rail. For all modes, other than automobile, access/egress costs or fares are included in the fare index and increase at approximately the same rate as the main terminal-to-terminal fares.

Service variables other than fares will not change significantly,

TABLE 22

PASSENGER TRANSPORT SERVICE VARIABLES, INDEXES TO 1990

(1980 = 100.0)

			SCENARIO I				SCENARIO II			
			Costs Only		All Variables		Costs Only		All Variables	
		1980	1985	1990	1985	1990	1985	1990	1985	1990
Fares:	CAR	100.0	109.6	111.1	109.6	111.1	106.2	104.3	106.2	104.3
	AIR	100.0	112.6	120.6	112.6	120.6	108.1	110.5	108.1	110.5
	RAIL	100.0	106.8	112.7	106.8	112.7	105.2	108.7	105.2	108.7
	BUS	100.0	106.8	112.7	106.8	112.7	105.2	108.7	105.2	108.7
Time:	RAIL	100.0	100.0	100.0	95.0	90.0	100.0	100.0	95.0	90.0
Freq:	RAIL	100.0	100.0	100.0	110.0	120.0	100.0	100.0	110.0	120.0
	BUS	100.0	100.0	100.0	105.0	110.0	100.0	100.0	105.0	110.0

except in rail. Under Scenarios I and II, rail travel times decrease on average by 1% annually and rail frequencies increase by 2% annually to 1990. These assumptions are broadly based on an interpolation of the various improvement scenarios being developed by VIA for the Windsor-Quebec corridor, where most Canadian rail travel takes place. Nationally, bus frequencies increase by only 1% annually to 1990, based on the requirement for increased capacity to meet future demand. No increase in air frequencies is forecast. Aircraft capacity is likely to increase on average so that existing traffic volumes could be carried by fewer planes. Similarly, the bus industry is testing the introduction of articulated buses with 50% more seats, but the extent of such innovations, as in the air mode, may be limited by the apparent marginal financial situation of the carriers. No changes are predicted as regards travel times for modes other than rail.

Base-year travel demand estimates are derived from an aggregation of all the interregional travel by car, air, rail and bus in the four 1980 Travel Surveys. These include an estimate of all travel in Canada for trips exceeding 50 miles and travel by Canadians in the U.S., but excludes travel by U.S. and other residents to and within Canada.

A new model was developed for this study. The model combines the simultaneous equation mode-specific, saturation and captivity effects of PERAM II with several new features. These include a self-normalizing technique for the stochastic part of the equation, ability to operate on datasets other than the original PERAM calibration dataset, such as the Travel Survey, ability to structure the mode share equations in sequential as well as simultaneous forms and a new set of equations that forecast average trip length and passenger-miles by mode in addition to person-trips by mode.

6.2.2 Forecasts

Highlights of the travel forecasts by mode to 1985 and 1990 are given in Tables 23-26. Growth in person-trips based on Travel Survey base-year figures is shown in Table 23, passenger-miles in Table 24, mode shares and average trip lengths in the following two tables.

Under Scenario I only very slow growth can be anticipated for the non-urban travel market as a whole. If only the cost variables are included in the model, total person-trips grow at 1.4% annually from 1980 to 1985, and at 2.3% from 1980 to 1990. If service is upgraded, the overall growth figures are unaffected, but the growth rates of rail and, to a lesser extent, bus are improved. Growth rates by air are very low as compared with past performance. This implies that should the air mode have to absorb such a cost increase as required by Scenario I, it will likely experience no growth. Some statements to this effect have recently been forthcoming from the air industry.

Yet these air results may be unduly pessimistic. As air fares rise in real terms, the high price-elastic non-business travel that has been attracted into air over the last decade or so by falling fares is likely to disappear. Consequently, the higher the fares become, the more will business travel come to dominate the air market, a situation characteristic of the 1950s and 1960s. These business travellers tend to have a lower price-elasticity than non-business travellers. Hence the air-fare sensitivity currently used in the model for total air travel may be overestimated for the future.

Scenario II assumes a more moderate increase in fares, reflected in the higher growth rates in Table 23. The increase in total travel is projected at 3% per year. However, growth by mode differs, largely owing to the contrasting cost assumptions made. Automobile costs are assumed to grow the slowest, so that the mode exhibits 3.1% annual growth. By contrast, the air mode is expected to experience the highest increases in costs, so that growth of 1.9% is forecast annually to 1990.[1]

Rail is the fastest-growing mode, with 4.6% average growth to 1990, reflecting improved service. But these growth rates are strictly a "what if" forecast because the extent and nature of the service improvements are uncertain at this time. Bus grows at a much slower rate than rail, owing to the differential effect of service improvements. Where only the cost variables are analysed by the model, the growth rates are identical bcause the cost input growth rates are identical.

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[1] For the official Transport Canada forecasts (contained in the 1982 Strategic Planning Guidelines), this growth rate for air travel was considered the "low" scenario.

TABLE 23

PERSON-TRIPS BY MODE, FORECAST GROWTH
(average annual percentage growth)

	SCENARIO I				SCENARIO II			
	Costs Only		All Variables		Costs Only		All Variables	
	1985	1990	1985	1990	1985	1990	1985	1990
Car	1.5	2.4	1.4	2.4	2.2	3.1	2.2	3.1
Air	0.3	0.6	0.3	0.6	1.4	1.9	1.4	1.9
Rail	2.6	2.1	5.0	4.5	2.6	2.2	5.0	4.6
Bus	2.6	2.1	3.0	2.5	2.6	2.2	3.0	2.7
Total	1.4	2.3	1.5	2.3	2.2	3.0	2.2	3.0

TABLE 24

PASSENGER-MILES BY MODE, FORECAST GROWTH
(average annual percentage growth)

	SCENARIO I				SCENARIO II			
	Costs Only		All Variables		Costs Only		All Variables	
	1985	1990	1985	1990	1985	1990	1985	1990
Car	-0.3	2.4	-0.3	2.3	1.7	4.5	1.7	4.4
Air	-2.6	-1.1	-2.6	-1.1	0.2	2.0	0.2	2.0
Rail	1.9	1.7	6.7	6.6	2.5	2.7	7.4	7.6
Bus	1.9	1.7	2.8	2.6	2.5	2.7	3.5	3.6
Total	-1.0	1.1	-0.9	1.2	1.2	3.5	1.3	3.6

TABLE 25

MARKET SHARES BY MODE, 1980-90
(percentages)

		SCENARIO I				SCENARIO II			
		Costs Only		All Variables		Costs Only		All Variables	
	1980	1985	1990	1985	1990	1985	1990	1985	1990
Car	87.2	87.4	88.4	87.1	88.0	87.4	88.4	87.2	88.0
Air	7.7	7.3	6.6	7.3	6.6	7.5	6.9	7.4	6.9
Rail	1.1	1.2	1.1	1.3	1.4	1.2	1.1	1.3	1.3
Bus	3.9	4.1	3.9	4.2	4.0	4.0	3.6	4.1	3.8
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

TABLE 26

AVERAGE TRIP LENGTH BY MODE, 1980-90
(miles)

		SCENARIO I				SCENARIO II			
		Costs Only		All Variables		Costs Only		All Variables	
	1980	1985	1990	1985	1990	1985	1990	1985	1990
Car	173	158	172	158	172	169	197	169	197
Air	1310	1133	1099	1133	1099	1234	1321	1234	1321
Rail	384	371	372	417	469	383	401	431	507
Bus	234	227	227	232	237	234	245	239	256
Total	266	235	238	236	240	254	279	255	281

Positive income growth and improved service levels tend to increase trip length; increasing fares tend to decrease it. The model estimates a net effect from these opposing forces. As shown in Table 26, total average trip length will decrease significantly under Scenario I but increase under Scenario II. There are, however, marked differences among modes. Under Scenario I, no material change is observed in the automobile trip length, but that by air falls sharply. These conclusions are affected only by relative costs, not by the service levels. Rail and bus experience slight declines in trip length owing to fare increases, but experience increases in trip length owing to the service improvements, substantial in the case of rail.

Under Scenario II all modes increase trip length, slightly in air, substantially in rail and automobile. Increased income outweighs the increased travel costs in this scenario. Effects of improved service are significant only for rail.

Passenger-mile forecasts are given in Table 24. These are the net result of the growth in trips and of the changing average trip length. The table shows a small-to-moderate increase in total passenger-miles but strong contrasts between the fortunes of different modes. Under Scenario I, car, rail and bus experience similar growth rates of around 2% annually, whereas air declines at about 1% annually to 1990. Introduction of service improvements raises the rail passenger-mile growth rates considerably while not materially affecting other modes.

Scenario II causes passenger-miles to grow faster than the rate for person-trips by some 0.5% annually, owing to increased trip length. Under this scenario all modes increase trip lengths: air by 2% annually, car by 4.4% annually to 1990. The difference is due to the increasing relative attractiveness of the automobile under Scenario II--the costs of other modes increase substantially faster than for the automobile. Service improvements boost rail passenger-miles significantly.

6.3 Urban Passenger

6.3.1 General

Intercity travel accounts for only a small portion of the total urban passenger-kilometres, estimated at 16% for 1980. Another 3% is by urban transit, with the remainder, 81%, accounted for by urban and rural auto traffic. Analysis of the latter segments of the transport sector is crucial to a study of total fuel consumption, but suffers from a lack of data. For purposes of trip generation analysis, intercity auto (9% of total passenger-kilometres) is included here with the rest of automobile travel.

6.3.2 Trends

Levels and rates of growth of population, households, automobiles and transit since 1951 are given in Table 27. Households and population increased at about the same annual rates in the decade 1951-61, but since then the two rates have increasingly diverged. Birth rates and the rate of population growth have fallen; household formation has increased because those persons reflecting the high post-war birth rates have matured into household formation.

The table also shows that after a rapid increase in 1951-61, the growth in automobiles has fallen as saturation levels in the proportion of households owning cars (currently almost 80%) are approached. The mode is still dominant, of course. From about 80% of total passenger-kilometres in 1951, automobile use has grown to account for an estimated 89% in 1980. A wide range of economic, social and demographic factors, in addition to population or household growth, have contributed to this increase.

Real disposable income per household, for example, grew on average at 2% a year over the three decades as households were increasing at a rate of more than 3% a year. The demand for automobiles has also been encouraged by relatively low costs of owning and operating a vehicle. The average price of an auto declined substantially in real terms in the 1960s and early 1970s, and gasoline prices were relatively stable until 1979 (see Figure 3).

Table 27

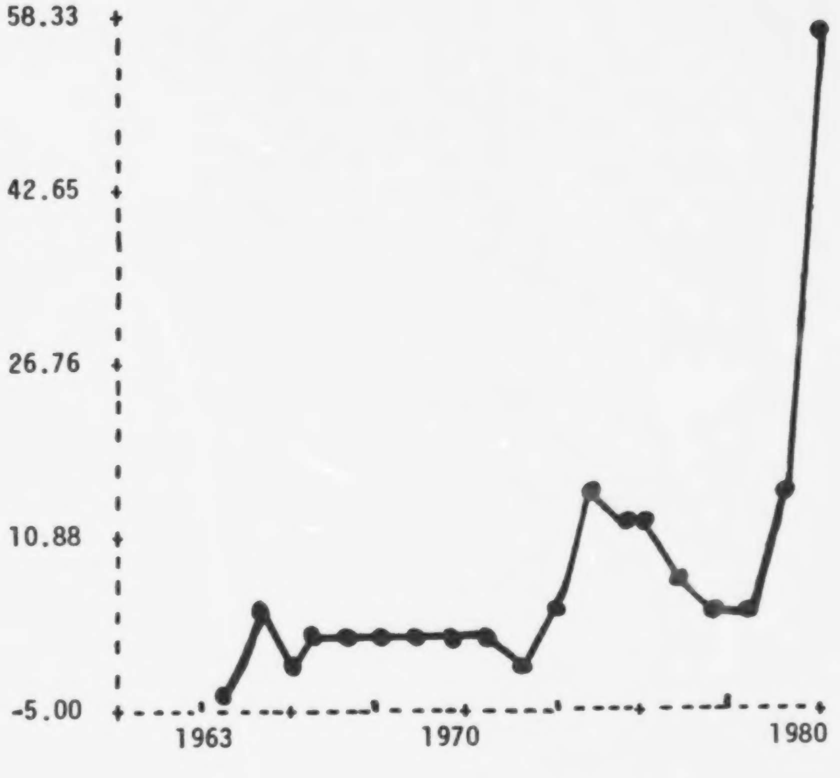
Population, Households, Automobiles and Urban Transit Trends in Canada - 1951-1980

Year	Fertility Rate	Annual Average Net Immigration	Total Population (millions) and Annual Rate of Increase %	Total Households (millions) and Annual Rate of Increase %	Total Automobiles (millions) and Annual Rate of Increase %	Urban Transit Usage (billions of rides) and Annual Rate of Increase %
1951	3.50	108,000	14.0 (2.7)	3.4 (2.9)	2.1 (7.5)	1.4 (-4.0)
1961	3.80	72,000	18.2 (1.7)	4.6 (2.8)	4.3 (4.9)	0.94 (0.3)
1971	2.19	120,000	21.6 (1.3)	6.0 (3.0)	7.0 (4.2)	0.97 (4.5)
1975	2.00	100,000	22.8 (1.0)	6.8 (3.3)	8.9 (3.0)	1.16 (2.0)
1980	1.8		24.0	8.0	10.3	1.28

Sources: Canada Year Books - Statistics Canada; Transit Fact Books - Canadian Urban Transit Association; Canadian Housing Statistics - C.M.H.C.; Rôle of the Automobile Study - Transport Canada 1976-1979.

FIGURE 3

RETAIL PRICE OF GASOLINE, PERCENTAGE CHANGE



The popularity of the auto is indicated by the existence of 10 million registered vehicles in 1980 compared with 2 million in 1951, so that cars per capita tripled over the same period. Since 1965, the percentage of households with two or more cars has doubled to 25% in 1980. Again, however, saturation levels may be close. But lower economic and demographic growth, lower increases in disposable income and, more recently, higher costs of owning and operating a vehicle are dampening the demand for automobiles and their use.

Table 27 also shows that from a level of 14 billion urban transit rides in 1951, transit use declined fairly rapidly. It stabilized in the 1960s and then increased from 1971 to 1980 owing to increasing policy emphasis on urban transit and subsidies to expand service and use.

Other implications can be drawn from the numbers in Table 27. Firstly, they show that household growth has become the "leader" in urban growth, that forecasts based on population growth are increasingly misleading, and that households should be used in any consideration of future urban growth and auto usage.

Secondly, the figures show that more than half the existing households have been established since 1951, during which time the auto population has quadrupled. Growth and development in the country has been closely linked with that of the automobile. For example, it has had a decisive effect on the form of cities.

The introduction of the automobile helped to reduce the overall density of urban areas by permitting more choice of potential destinations or more suburbs. It also brought a dispersal of employment and service centres, which now depend on the automobile. Transit service, on the other hand, caters to a large proportion of peak-period trips to and from the core of larger cities. The dispersal of destinations away from the centre, the growth of dispersed non-work trips, and low-density residential areas have been encouraged by the automobile.

In conjunction with a near doubling of average real income per household since 1951, households have traded up to new dwellings. With net household formation concentrated in the lower age groups, apartments have played an increasing part in urban growth until fairly recently, increasing from 13% of national dwelling completions in 1951 to more than 50% in 1968 and 1969, but falling back gradually to about 45% of completions in 1980, as demand for and supply of single family dwellings increased. The trend of urban housing by dwelling type and density has tended toward apartments and/or row housing in more difficult circumstances, particularly with falling birth rates, more women working, and smaller households. In any event, the present housing stock, being fairly new, fixed and durable, will probably be occupied to at least the end of the century and that major change in urban land use is unlikely over the next decade.

6.3.3 Economic and Demographic Forecasts

Although total population is expected to increase from 24 million in 1980 to only 26 million in 1990, more than 85% of the net increase in population will be concentrated in the 25-54 age groups. These age groups, which have a high propensity to work and travel, are expected to increase in size by 21% over the decade. With an increase in the overall labour force participation rate from 64% in 1980 to about 68% by 1990, the civilian labour force will increase from 11.5 million in 1980 to 13.7 million by 1990, a 19% increase.

In terms of population of driving age (over 16) and drivers' licenses, a 1979 survey showed that some 78% of the population of driving age were licensed, 94% for men and 63% for women. This driving age group is already expected to increase substantially over the decade. If women catch up with men in terms of drivers' licensing, the number of licensed drivers would increase by a further 25% to about 40%, a similar rate of increase to that experienced in Ontario from 1969 to 1979.

Growth of households (i.e., a person or group occupying a separate dwelling) is expected to be strong over the decade, from 8 million in 1980 to about 10 million in 1990. Inflation, high interest rates and rent controls, however, may retard housing growth somewhat below these rates and keep the actual rate of household formation below demographic rates. For example, in 1980 there were 176,000 housing completions, but an estimated need for 220,000. The expected provincial distribution of households (allowing for internal migration as well as natural increase) is given in Table 28.

The table shows, almost inevitably, that Alberta will be the leader in household growth over the decade (+47%), followed by B.C. (+32%). with Manitoba, Saskatchewan and Quebec below the national average. The nation's households are heavily concentrated (59%) in the 23 Census Metropolitan Areas (CMAs), and these major urban areas are expected to show a slight increase in their share of the nation's households. Because the household tends to be the crucial auto-owning and auto-trip-generating unit, and because the CMA is the most dynamic demographic factor and the origin or destination of most trips, CMA households will generate most of the expected increase in urban traffic and in rural and inter-city traffic.

Thus, the next decade offers continued growth in demand for automobiles as the population ages and new households are built, although there will be a leveling off as ownership saturation levels are reached. Furthermore, although some efforts may be made to modify urban land use by increasing the density of city centres or sub-centres, a generally dispersed city populace will remain, relying on the automobile.

6.3.4 Traffic Forecasts

a. Auto

First of all, travel to and from work was considered. This represents about 40% of all auto trips generated from all origins and closer to 50% of auto trips in the core of CMAs. A structural type of model was used to forecast commuting travel, where total kilometres driven by CMA was derived by multiplying the number of households by average auto trip length and by the number of trips per household.

Household forecasts were obtained from the Central Mortgaging and Housing Corporation (CMHC). The number of work days per year were assumed to remain constant and there would be 1.2 occupants per auto and one auto commuter per household. Average auto trip length to work was derived as a function of the average distance of dwellings from the centre of each CMA.

Although auto trip lengths to and from work seem likely to increase only slightly, about 10% over the decade, total auto trip-to-work kilometres may increase by more than 3% a year as a result of the expected growth in household formation. Again, this assumes other things being equal such as auto occupancy and propensity to travel by auto. Slower growth is expected in travel-to-work kilometres in non-CMA urban and rural areas, giving a total growth from all origins of 2.6%.

For non-commuting trips, the best that could be done was to use available evidence on annual auto kilometres per household by origin and trip purpose, and again apply forecast growth in households. A projection of 2.9% average annual growth was derived for all origins for 1980-1990, with slightly more growth in CMA areas than in smaller cities or rural areas (including intercity travel).

These results are summarized for all trip purposes in Table 29, indicating a change in the urban/rural split from 52/48 in 1980 to 55/45 in 1990.

b. Urban Transit

Total revenue passengers carried on urban transit declined up to 1965, but then increased at about 2% a year on average up to 1980, with increasing subsidies to the mode and a falling number of passengers per vehicle-kilometre. There is evidence of increasing average trip length. Passenger-kilometres have almost doubled from 5.4 billion in 1971 to 10.5 billion in 1980; this figure was still, however, only about 7% of total urban passenger-kilometres.

Unlike the automobile, which functions well for dispersed trips for a wide range of purposes, transit is essentially a centre-oriented system with most trips for work or education reasons. In the absence of major crises, little change is expected to 1990 in these roles. The trend toward constant (but longer) trips per capita can be expected to continue with passenger-kilometres increasing at a slower rate than in the 1970s, about 3.4% per year to 1990, from 10.5 billion to 14.7 billion.

6.4 Freight

Freight forecasts by DGEA are done for selected commodities accounting for most of the transport activity in each region of Canada. Forecasts are made using many techniques ranging from detailed econometric models to market analysis and incorporating the results of studies in other government departments and agencies.

Growth in loadings and unloadings of freight to 1990 is summarized in Table 30. In accord with the economic outlook for Canada under the first energy price scenario, moderate growth in freight activity (3.4% per year in total shipments) is expected. Rail tonnage should increase by 4% a year to 1990, while marine and truck loadings will grow at 3.5% and 3.6%, respectively. Within this global picture, movements of certain key commodities are continuing their recent rapid growth, for example, rail and international marine loadings of grain, coal, potash, sulphur and iron ore.

Data on fuel consumption by commodity, the basis on which the DGEA freight forecasts are done, is extremely hard to obtain. Total fuel consumption by the intercity freight sector has therefore been projected on a modal basis with the above growth rates and with assumptions made for improvements in energy efficiency by mode.

Nevertheless, it is important to remember that the fuel consumption effect of some commodity movements can differ from the growth rates of the commodity shipments themselves. For example, Western Canadian grain exports will be growing at 4% to about 1985 and 2.9% annually thereafter. This translates into exports of 26.9 million tonnes and 31.4 million tonnes, respectively, in 1985 and 1990. The grain movement will likely be: by truck from the farm to primary elevators, by rail from primary to terminal elevators, transshipment by laker and rail in eastern Canada to St. Lawrence and Atlantic ports, and export from five different clearance sectors (Pacific Coast, Churchill, Thunder Bay, St. Lawrence ports, Atlantic ports).

Freight demand for grains is expected to generate a fuel requirement exceeding 1 billion litres in 1990, or 17.2 thousand barrels per day, 2% of the projected NEP demand for transportation fuels in 1990. The demand for fuel will break down as: 3% for truck, 40% for rail, 8-9% for transshipment (both rail and marine) and 47-49% for overseas shipments. Because of the projected shift to West Coast ports in grain exports, which will in 1990 account for 50% of grain clearances compared to 46% in 1985, higher fuel consumption per ton for both rail shipments to terminals and overseas clearances will result. Foreign shipments of resource commodities from western Canada are subject to large overland costs, owing to distance and difficult terrain. This will cause total fuel consumption to grow faster than the total growth in tonnage of grain shipped: 21% versus 17% between 1985 and 1990.

The sensitivity of the freight sector to different energy price cases was handled in a manner different from that for passenger.

Forecasts of total tonnage shipped were produced for the base case (the NEP/Agreement energy prices) and the effect of the second scenario was tested for the sector as a whole, not item by item. This was done because most of the detailed freight forecasting is for major bulk commodities. Most of the demand for these is generated outside Canada and is not significantly affected by domestic oil pricing schedules except in-so-far as these are reflected in the cost of commodities. Because these commodities are "captive" to certain modes, e.g., grain shipments to the rail and marine modes, the choice of mode is essentially unaffected by transportation cost increases resulting from fuel price increases.

To test this hypothesis of insensitivity to fuel prices, an equation was used which relates freight output by mode to industry (modal) prices. These modal prices, or tariffs to the shipper, were assumed to increase at the same rate as fuel prices, and the effect on traffic of the second fuel price scenario was examined. As expected, the effect proved to be almost insignificant. Only in marine loadings to 1990 was the difference above 2%.

The implication that different fuel price scenarios have a much more marked effect on passenger than on freight modes refects the external versus domestic generation of the demand for transportation and the degree to which major freight shipments are captive to particular mode.

TABLE 28

PROVINCIAL DISTRIBUTION OF HOUSEHOLDS, 1980 AND 1990

Province	No. of Households (000s) 1980	1990	Increase (000s)	%
Newfoundland	149	186	+ 37	+25
P.E.I.	36	45	+ 9	+25
Nova Scotia	269	327	+ 58	+22
New Brundswick	215	268	+ 53	+25
Quebec	2,098	2,501	+ 403	+19
Ontario	2,940	3,643	+ 700	+24
Manitoba	360	418	+ 58	+16
Saskatchewan	320	378	+ 58	+18
Alberta	692	1,014	+ 322	+47
British Columbia	939	1,235	+ 296	+32
Canada	8,018	10,015	+ 1,997	+25

Source: Population, Households and Housing Requirements, 1976-2001. CMHC, 1981.

TABLE 29

ESTIMATED AUTO KILOMETRES IN URBAN AND RURAL AREAS, 1980-90

Area	1980	%	1990	%	% Increase 1980-1990
Inside 23 CMAs	70	41	98	43	+40
Inside Smaller Urban Areas	19	11	26	12	+37
In Rural Areas (incl. inter-city)	83	48	103	45	+25
	172	100	227	100	+33

TABLE 30

FREIGHT FORECASTS TO 1990
(% average annual growth in tonnage)

	Rail		Marine		Truck	
Region	Loadings	Unloadings	Loadings	Unloadings	Loadings	Unloadings
Atlantic	5.3	5.3	1.8	1.2	4.7	4.6
Quebec	3.2	4.3	3.7	1.4	2.7	2.6
Ontario	1.9	1.7	0.2	2.7	3.7	3.8
Prairies	4.4	3.7	-	-	4.2	4.2
B.C.	5.6	6.0	5.3	0.7	3.5	3.5
Canada	4.1	4.2	3.5	1.7	3.6	3.6

7. FUEL CONSUMPTION

7.1 General

The main objective of this study was to determine the likely demand for petroleum products by the Canadian transport sector in the 1980s. Contained in the 1980 National Energy Program was a target of zero growth in transport fuel use which, if achieved, would be a major contribution to the goals of conservation and self-sufficiency. The issue addressed here was the possibility of meeting that target, with expected growth conditions in the economy and transport industry, under two scenarios on energy prices.

Consistent with the forecasts for the economy, prices, technology and transport demand, this study now presents forecast levels of fuel consumption. In the preparation of these forecasts, DGEA encountered the same problems as in the transport demand forecasts, such as the lack of data on various classes of road vehicle, their numbers and movement as well as fuel use. Other difficulties include deficiencies in analytical techniques for fuel demand models.

7.2 The Transportation Energy "Cap"

The National Energy Program had as one of its objectives a "cap" on total oil consumption in the transport sector at about the 1979 level. In the initial NEP report, the 1979 level of oil consumption was given as 870,000 barrels per day, and the target 1990 level was 865,000 barrels per day, a very slight decrease. The residential and commercial sectors, meanwhile, were to halve their oil consumption, while other consumers kept theirs steady.

Since the NEP was proclaimed, there has been no public revision of this target level of oil consumption for the transport sector. An examination of the background figures from Energy, Mines and Resources, indicates that the "cap" was even expected to fit a little tighter than initially publicized. Their figure for actual transport oil consumption in 1979 was 894,000 barrels per day, and their target level 856,000 barrels per day.

The "cap" was not derived by simply holding overall transport crude

TABLE 31

FUEL DEMAND FORECASTS CONTAINED IN NATIONAL ENERGY PROGRAM
(mill. barrels)

		Actual	Forecast	
		1979	1980	1990
Road:	Gasoline	240.47	246.01	222.64
	Diesel	20.34	21.25	30.91
	Total	260.81	267.26	253.55
Rail:	Diesel	18.89	18.61	21.64
	Heavy Fuel Oil	.82	.80	.97
	Coal	.16	.12	.06
	Total	19.87	19.53	22.67
Air:	Turbo	26.82	27.08	24.62
	Gasoline	1.71	1.69	1.28
	Total	28.53	28.77	25.90
Marine:	Heavy Fuel Oil	10.89	10.47	10.76
	Diesel	6.30	6.12	6.95
	Total	17.19	16.59	17.71
GRAND TOTAL		326.40	332.15	319.83
BARRELS PER DAY		894,000	910,000	876,000
Less reduction due off-oil programs				21,000
Equals: total refined product consumption (barrels per day)				855,000
(million litres per day)				135.9

oil consumption constant. Rather, the goal in barrels per day was stated in terms of a number of different products. For each mode and type of fuel, EMR modelled and estimated demand in 1990. The total of the various fuel demands makes up the "cap" of 856,000 barrels per day, after allowance for "off-oil" (propane) programs. The mix of product types in demand was expected to change. The ratio of gasoline to diesel in road use, for example, was expected to be roughly 85/15 in 1990, as compared to 90/10 in 1979, and the total quantity of both in road use was to be down by 3% by 1990, with gasoline down by 7% and diesel up by 52%.

Similarly, total fuel use in aviation was expected to decline roughly 9% over 1979-90, while that in rail was expected to rise 14%. Marine fuel use, by contrast, was to increase only 3%.

Because DGEA's transportation demand projections for the 1980s, produced at the same time, showed firm growth per year in freight and in passenger, these expected changes in fuel use caused some concern. EMR has not enunciated whether the individual "caps" for different refined products are as important as the overall target level, but it was obviously important for Transport Canada to examine these in the light of its own strategic planning forecasts.

7.3 Recent U.S. and Foreign Experience

Canada did not experience in the 1970s the price increases in transportation fuels faced by other industrialized countries. In 1977, for example, Italy and Japan had real motor gasoline prices rise more than 30% above their 1970 levels. In Canada, by contrast, the real price of motor gasoline in 1977 was only 8% above its 1971 level (see Figure 4). Furthermore, recent work by the OECD showed Canada ranking last among seven industrialized nations in terms of real energy prices to final users in the transportation sector (see Figure 5).

Although each country has a different set of institutional and economic circumstances, a review of foreign experience under sudden, sharp price rises is of interest. For this purpose DGEA used, as source documents, studies done by the U.S. Dept. of Energy on international comparisons of motor gasoline demand and price (to the year 1977) and by N.D. Lea for the Ontario Ministry of Transportation and Communications. The latter study includes an extensive review of more recent U.S. experience, including intercity and interstate comparisons.

The results of the international comparison to 1977 (see Tables 32 and 33) indicate the sensitivity of gasoline consumption to changes in price. The authors of the study estimated a short-run price elasticity of gasoline demand ranging from -0.1 to -0.3, depending on the country (see Table 34). The price elasticity, however, can be outweighed by the income elasticity of demand, which measures the response of consumption to changes in income, a positive relationship. This was estimated as ranging between 0.3 to 1.0, depending on the country. Both types of elasticity are greater in the long term than in the short term, because the long term allows for adjustments through buying or selling vehicles, etc.

All the countries experienced declining incomes (owing to rising energy prices in general) at the same time as they experienced rising gasoline prices, and it is difficult to establish which factor caused the drop in consumption. The authors of the U.S. Department of Energy report concluded that Japan and Italy were the two countries that experienced the greatest 'induced' reduction in consumption over 1973-1977, as compared to what consumption might have been had the oil embargo not occurred. In Japan, the reduction of about 15% was mainly due to slow growth in national disposable income, which had been growing at 10%, but dropped to 3% between 1973 and 1977. In Italy, conversely, price was the major causal factor in a 17% reduction. Much of the increase in Italian

FIGURE 4

REAL GASOLINE PRICE INDEXES, CANADA AND U.S.A.

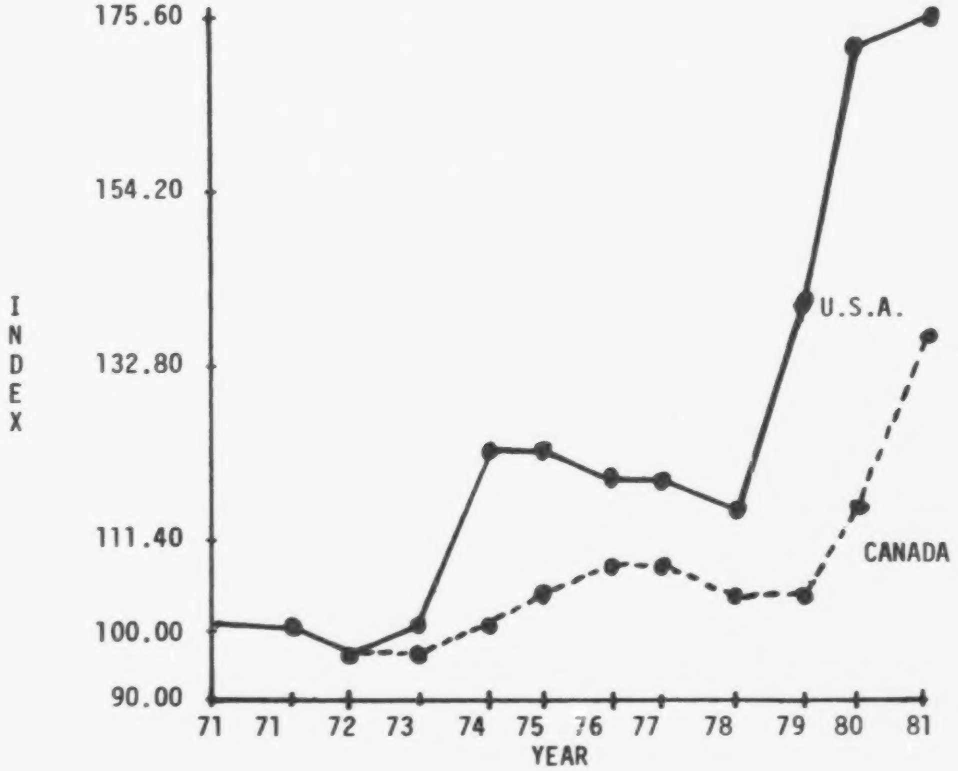
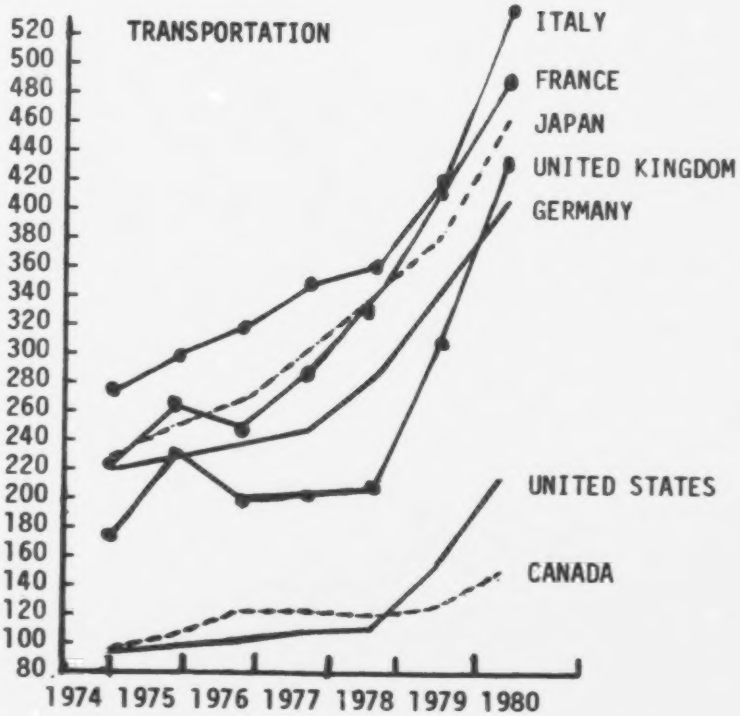


FIGURE 5

ABSOLUTE ENERGY PRICES TO FINAL USERS, TRANSPORTATION
(United States 1975-100, adjusted for changes in exchange rates)



Source: OECD Economic Outlook, #29, July, 1981

TABLE 32

ANNUAL RATES OF GROWTH IN THE CONSUMPTION OF MOTOR GASOLINE

(Growth as a percentage of the previous year)

Year	United States		Japan		France		West Germany		Italy		United Kingdom		Canada	
1971	4.0		8.8		9.3		11.0		4.3		5.1		4.6	
1972	6.4	4.9	9.3	9.1	9.4	9.8	5.5	6.1	8.3	7.3	6.2	5.9	7.2	7.0
1973	4.3		9.1		10.7		1.9		9.3		6.5		9.3	
1974	-2.1		0.5		-3.4		-2.5		-7.1		-2.6		3.1	
1975	2.1		8.7		5.2		14.4		11.8		-0.8		5.0	
1976	4.8	3.2	6.4	6.6	5.2	3.9	-0.6	6.6	-3.1	2.0	4.7	2.2	1.9	3.2
1977	2.6		4.6		1.4		6.1		-2.6		2.7		2.8	

Source: Technical Report, "Income and Price Effects on Petroleum Consumption, An International Comparison", U.S. Dept. of Energy, 1980, quoted in N.D. Lea, "Impact of Petroleum Supply and Pricing Upon The Demand for Transportation Services", 1981.

TABLE 33

INDEX OF REAL RETAIL PRICES FOR REGULAR MOTOR GASOLINE (1970=100)

Year	United States	Japan	France	West Germany	Italy	United Kingdom	Canada
				INDEX			
1970	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1971	97.7	99.1	96.8	95.3	101.2	94.4	99.1
1972	96.3	101.8	93.2	93.4	102.7	89.3	96.6
1973	112.2	126.7	105.9	101.5	103.5	91.1	94.8
1974	123.9	136.3	115.2	109.5	122.0	119.1	98.3
1975	117.0	132.6	106.4	111.1	128.2	124.6	100.9
1976	115.8	135.8	108.0	111.3	144.1	114.7	105.2
1977	113.9	130.5	110.4	108.4	149.9	101.3	106.0
			ANNUAL RATE OF CHANGE				
1971	-2.3	-0.9	-3.2	-4.7	1.2	-5.6	-0.9
1972	-1.4	2.7	-3.7	-2.0	1.5	-5.4	-3.0
1973	16.5	24.5	13.6	8.7	0.8	2.0	-1.9
1974	10.4	7.6	8.8	7.9	17.9	30.7	-3.7
1975	-5.6	-2.7	-7.6	1.5	5.1	4.6	2.6
1976	-1.0	2.4	1.5	0.2	12.4	-7.9	4.3
1977	-1.6	-3.9	2.2	-2.6	4.0	-11.7	0.8

Source: Technical Report, "Income and Price Effects on Petroleum Consumption, An International Comparison", U.S. Dept. of Energy, 1980, quoted in N.D. Lea, "Impact of Petroleum Supply and Pricing Upon the Demand for Transportation Services", 1981.

TABLE 34

ESTIMATES FOR PRICE AND INCOME ELASTICITY OF DEMAND FOR GASOLINE, U.S. AND OTHER OECD COUNTRIES IN THE EARLY 1970's.

	UNITED STATES	OTHER OECD COUNTRIES
Price		
Short Run	-0.1 - -0.2	-0.1 - -0.3
Long Run	-0.4 - -0.9	-0.3 - -1.6
Income		
Short Run	0.3 - 1.0	0.3 - 0.9
Long Run	0.8 - 1.1	0.8 - 1.9

Source: A number of studies, summary provided in U.S. DOE report. (See Source: Table 32.)

gasoline price was due to increased taxes, which rose about 35% in 1977 alone.

The study by N.D. Lea concluded that of the 17% reduction below trend projection that occurred in U.S. gasoline consumption since 1972, about 3% was due to the reduction of the highway speed limit to 55 m.p.h., and the balance partly due to regulation and partly to increased prices. According to the authors, fuel economy regulation could not have been effective during the short crises, and what price controls were put into place could only have worked to increase consumption, not to decrease it. Therefore the question was whether restricted supply was more important than the price effect in reducing consumption. The study examined U.S. experience in 1974 and 1979, and concluded that during the two 'crises', price increases were what caused the reduction in demand for gasoline--not the de facto rationing and queuing.

In each crisis, the restriction of supply was accompanied by rapid price rises. For example, in 1974, Boston, Washington and Denver all experienced about a 50% price increase. Denver did not experience the queues seen in the other two cities, but in all three the 1974 level of traffic in the city was about 5% below trend expectations. Similarly, from 1978 to 1979 price increases were fairly uniform across the U.S. while queuing varied considerably from state to state. Actual reductions in fuel consumed, however, were generally about the same. Both these cases support the argument that the reduction was due more to price than to restriction in supply.

7.4 Current Levels of Consumption in Canada

Before forecasts of fuel use in Canada are examined, base year levels are presented here. The energy policy target, or "cap", was derived by EMR in terms of consumption by fuel type. Table 35 presents the breakdown in 1970 and 1980 of the various types of fuel consumed in transport. In Table 36, an attempt is made to allocate fuel use in 1980 by mode. The task of estimating fuel consumption by mode is especially difficult for road vehicles because Statistics Canada does not indicate whether road fuels go to truck, bus, transit or private vehicle. Because these modes account for so much of total fuel consumption, it is unfortunate that more precise knowledge is lacking as to what kinds of vehicle use are responsible for what shares of the total. Current data efforts with Statistics Canada may help remedy this situation.

TABLE 35

TRANSPORT FUEL CONSUMPTION BY TYPE OF FUEL

	1970		1980	
Fuel	Mil. Litres	% of Total	Mil. Litres	% of Total
Gasoline (1)	26,908	75.2	38,477	70.2
Diesel (2)	4,068	11.4	9,052	16.5
Heavy Fuel Oil (2)	1,901	5.3	2,444	4.5
Turbo (3)	2,659	7.4	4,575	8.4
Aviation Gasoline (3) (total)	242	0.7	238	0.4
TOTAL	35,778	100.0	54,780	100.0

(1) Includes agricultural use.
(2) Transportation industry only, exclusive of pipelines.
(3) Includes public administration, commercial.

Source: Statistics Canada

TABLE 36

TRANSPORT FUEL CONSUMPTION BY MODE[1]

Mode	Fuel Consumption (mil. litres)	%
Auto and Taxi (Urban, Rural and Intercity)	25,464 gasoline	46.5
Light Truck (up to 5 tons, personal, service and freight)	10,394 gasoline	19.0
Medium and Heavy Truck	2,599 gasoline	4.7
	4,951 diesel	9.0
Bus (Intercity and Transit)	20 gasoline	-
	408 diesel	0.7
Rail (Passenger and Freight)	2,435 diesel	4.4
Marine	1,258 diesel	2.3
	2.444 heavy oil	4.5
Air	4,575 turbo	8.4
	238 aviation gasoline	0.4
TOTAL	54,780	100.0

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[1] Consumption by road modes is estimated.

Source: Statistics Canada

7.5 Forecast Levels of Consumption

7.5.1 Gasoline by Automobiles

This is a crucial area of forecasting because gasoline consumption by automobiles represents about 50% of consumption of all petroleum fuels in transport. Compared with other road modes there is a large amount of data for analysis, but there are deficiencies in key areas such as vehicle use and survival rates. There have been many attempts to model and forecast gasoline consumption, using techniques ranging from purely engineering to econometric[2], and the results of a few of these are described here. However, none of them are completely satisfactory and further research is underway to obtain or develop a more suitable model.

In the meantime this study presents a number of previous approaches and their forecasts. These differ considerably, reflecting an emphasis on different determining factors. The forecast selected here is for total gasoline consumption, described in section 7.5.2. This approach avoids the difficult tasks of forecasting consumption by road vehicles other than automobiles, where data limitations are severe, and is able to meet the primary objective of this study: to forecast total fuel requirements.

One type of passenger car fuel consumption model takes a technical approach. It pre-specifies the total kilometres desired by auto travellers, as predicted in Section 6.3.4, makes some assumptions on fuel consumption rates and survival rates of automobiles, and derives the new car sales required each year to satisfy that demand.

Thus, total auto kilometres are projected to increase to 227 billion by 1990 from 172 billion in 1980. In addition, test fuel consumption rates of new cars are expected to reach 7.65 litres/100 km. from 10.5 litres/100 km. in 1980 (or 37 m.p.g. from 27). Actual rates in 1979 were 1.18 times test rates, and this is assumed to hold in the future.

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[2] Further discussion of fuel demand models is contained in DGEA, Transportation Energy Demand Forecasting Models, November 1981.

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With assumptions on survival rates and fuel consumption rates by model year, the projected total distance travelled implies an average fleet fuel consumption of 11.4 litres/100 km. (25 m.p.g.) in 1990 compared with 14.8 litres/100 km. in 1980 (19 m.p.g.). This, in turn, implies total fuel consumption of 23.4 billion litres, compared with the 25.5 billion litres consumed in 1980.

With this technical approach, automobile fuel consumption is therefore projected to drop by 8% from 1980 to 1990. This result depends on many factors though.

- It requires that new car sales increase from just less than a million per year on average from 1977-80 to 1.4 million in the year 1990. These sales volumes mean a fleet size of 13.4 million in 1990, or more than 0.5 automobiles per capita, compared with a 1980 level of 0.43 per capita. Such a level may, however, exceed a saturation level of car ownership.

- It is highly sensitive to the fuel consumption rate. Only a slight deterioration is needed for total fuel requirements to remain at the 1980 level of 25.5 billion litres.

- It does not take into account behavioural relationships, such as that between gas prices and auto use or between prices and sales of new cars. For example, average kilometres driven per automobile are assumed to remain relatively constant at about 16,800-17,000 kilometres a year, in spite of the downsizing of vehicles and the real increase in price of gasoline.

A second type of model, the National Energy Board's model (MOGAS), combines a technical approach with some behavioural relationships. It uses survival rates, average distances driven and fuel consumption rates by model year. Unlike the first approach, however, which pre-specified the total kilometres desired by auto travellers and then derived the new car sales required to satisfy that demand, MOGAS includes regression equations that determine the amount of new car sales and the mix of large and small cars. With its variety of input variables, this model seems to cover the essential components affecting gasoline consumption and permits the testing of a wide range of scenarios. DGEA obtained the model from the National Energy Board and re-estimated it, using data for the period 1966-80.

For the NEP/Agreement scenario, the model forecasts an enormous drop in the consumption of gasoline by automobiles, down 47% in 1990 from the 1980 level. This results from a drop in the fleet size from 10 million in 1980 to 8.5 million in 1990, or to 0.36 cars per capita, plus a decrease in average annual mileage driven per automobile (from close to 10,000 miles per year in 1980 to less than 9,000 in 1990), and from expected improvements in fuel economy. Use of the lower fuel price scenario in MOGAS did not make a substantial difference, projecting a drop of 44% in fuel consumption.

These results, however, are open to serious question. The expected reduction in size of the fleet results from sales of new cars falling from close to a million on average in 1977-80 to 633,000 in the year 1990. This is inconsistent with the expected growth in households and the continued reliance on automobile travel (see Section 6.3.3 above). Similarly, the reduced mileage is questionable, given expected requirements for auto use. In the model, average mileage per vehicle depends on the age of the automobile, with coefficients established in the mid-1970s. Efforts are being made to improve such key elements of the model, and in the meantime DGEA does not accept the forecasts it generates.

Another simple approach was to combine the projections of fuel intensity (gallons per passenger-mile, Table 21) with forecasts of passenger-miles (in Sections 6.2.2 and 6.3.4). This is possible only for the two scenarios for intercity travel because it is only for this sector that total passenger-mile estimates were made sensitive to alternate scenarios. The results, however, could be extended to the other travel sectors.

As described previously, intercity passenger-miles by automobile are expected to decline slightly to 1985 under the NEP/Agreement scenario but increase by 28% from 1985 to 1990. The effect of lower fuel price increases is reflected in the second scenario where passenger-miles increase by 54% over the 10 year period. Applying the 33% improvement in fuel efficiency assumed in Table 21 means a gasoline consumption decline of 17% from 1980 to 1990 under the NEP/Agreement scenario and an overall increase of 2% in consumption under the second scenario. The pattern through the intervening years, as expected, has declining consumption, in the early 1980s, and recovery after 1985.

With respect to urban/rural travel, a 33% increase in passenger-miles by automobile under the NEP/Agreement scenario, along with the fuel efficiency improvement, would imply a decline of 15% in gasoline consumption in this sector to 1990. It is not possible to determine the effect on this travel sector of alternate scenarios, since the estimates for urban/rural passenger-miles were independent of fuel costs for the sector. One possible assumption is that the second scenario on automobile fuel costs will have an effect similar to that on intercity travel, i.e., no decline in gasoline use for the total period, and possibly a small increase.

The difficulty with this last approach is simply in the magnitude of the decline in gasoline consumption to 1990, 15-17% in the base scenario, with the decline concentrated in the early 1980s. But, large cutbacks in consumption are not occurring in response to large gasoline real price increases (see Figure 3). There have been reductions, but not of the order predicted. Such predictions also result from behavioural models, estimated with historical data up to 1980. Unless there is to be a delayed reaction by consumers, which would be captured with built-in lags, these models are just not equipped to handle the current price shock.

One approach appearing more successful for longer-term projections is a formula that relates auto kilometres to the number of households, real income per household, real variable costs and real fixed costs of driving an automobile. Elasticities associated with the latter three variables were assumed to be 0.63 for income, -0.38 for variable cost and -0.25 for fixed costs. In this specification growth in households tends to offset the effects of changes in gasoline and auto prices. The expected fleet fuel economy was applied and forecasts for automobile gasoline consumption were determined. Under the NEP/Agreement scenario, this approach predicted that consumption would drop by 3% from 1980 to 1990. The second scenario, with gasoline prices in constant 1980 dollars expected to reach 38.8 cents a litre in 1990, implies an increase of 3% in gasoline consumption by automobiles over the decade.

7.5.2 Total Gasoline

This study required a forecast of total gasoline consumption, not just that by automobiles. As seen in Table 36, one-third of the gasoline consumed in 1980 was by vehicles other than automobiles and taxis. Lack of data on these vehicles (mainly light trucks), their use and their fuel consumption, precluded separate quantitative analysis. Thus, an equation was specified for total drop in the consumption of gasoline by automobiles, down 47% in 1990 from the 1980 level. This results from a drop in the fleet size from 10 million in 1980 to 8.5 million in 1990, or to 0.36 cars per capita, plus a decrease in average annual mileage driven per automobile (from close to 10,000 miles per year in 1980 to less than 9,000 in 1990), and from expected improvements in fuel economy. Use of the lower fuel price scenario in MOGAS did not make a substantial difference, projecting a drop of 44% in fuel consumption.

These results, however, are open to serious question. The expected reduction in size of the fleet results from sales of new cars falling from close to a million on average in 1977-80 to 633,000 in the year 1990. This is inconsistent with the expected growth in households and the continued reliance on automobile travel (see Section 6.3.3 above). Similarly, the reduced mileage is questionable, given expected requirements for auto use. In the model, average mileage per vehicle depends on the age of the automobile, with coefficients established in the mid-1970s. Efforts are being made to improve such key elements of the model, and in the meantime DGEA does not accept the forecasts it generates.

Another simple approach was to combine the projections of fuel intensity (gallons per passenger-mile, Table 21) with forecasts of passenger-miles (in Sections 6.2.2 and 6.3.4). This is possible only for the two scenarios for intercity travel because it is only for this sector that total passenger-mile estimates were made sensitive to alternate scenarios. The results, however, could be extended to the other travel sectors.

As described previously, intercity passenger-miles by automobile are expected to decline slightly to 1985 under the NEP/Agreement scenario but increase by 28% from 1985 to 1990. The effect of lower fuel price increases is reflected in the second scenario where passenger-miles increase by 54% over the 10 year period. Applying the 33% improvement in fuel efficiency assumed in Table 21 means a gasoline consumption decline of 17% from 1980 to 1990 under the NEP/Agreement scenario and an overall increase of 2% in consumption under the second scenario. The pattern through the intervening years, as expected, has declining consumption, in the early 1980s, and recovery after 1985.

With respect to urban/rural travel, a 33% increase in passenger-miles by automobile under the NEP/Agreement scenario, along with the fuel efficiency improvement, would imply a decline of 15% in gasoline consumption in this sector to 1990. It is not possible to determine the effect on this travel sector of alternate scenarios, since the estimates for urban/rural passenger-miles were independent of fuel costs for the sector. One possible assumption is that the second scenario on automobile fuel costs will have an effect similar to that on intercity travel, i.e., no decline in gasoline use for the total period, and possibly a small increase.

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One approach appearing more successful for longer-term projections is a formula that relates auto kilometres to the number of households, real income per household, real variable costs and real fixed costs of driving an automobile. Elasticities associated with the latter three variables were assumed to be 0.63 for income, -0.38 for variable cost and -0.25 for fixed costs. In this specification growth in households tends to offset the effects of changes in gasoline and auto prices. The expected fleet fuel economy was applied and forecasts for automobile gasoline consumption were determined. Under the NEP/Agreement scenario, this approach predicted that consumption would drop by 3% from 1980 to 1990. The second scenario, with gasoline prices in constant 1980 dollars expected to reach 38.8 cents a litre in 1990, implies an increase of 3% in gasoline consumption by automobiles over the decade.

7.5.2 Total Gasoline

This study required a forecast of total gasoline consumption, not just that by automobiles. As seen in Table 36, one-third of the gasoline consumed in 1980 was by vehicles other than automobiles and taxis. Lack of data on these vehicles (mainly light trucks), their use and their fuel consumption, precluded separate quantitative analysis. Thus, an equation was specified for total gasoline consumption per capita; it was dependent on disposable income per capita, the real price of gasoline and consumption per capita in the previous year. Data was used for 1968-1981, and an average price elasticity of -0.16 was derived. Under the NEP/Agreement scenario, this resulted in a total decline in gasoline consumption of 5% to 1980 to 1985, followed by a recovery in consumption as price increases decline and real disposable income improves. The 1980 level would be exceeded, therefore, by 6% in 1990. This is plotted as Scenario I in Figure 6.

Under the alternative scenario (plotted as II in Figure 6) where fuel prices increase slower and real income growth is stronger, consumption of gasoline increases marginally to 1985 following the 1981 decline. A more substantial increase follows later in the period when the real price of gasoline is expected to peak in 1987-88 and decline thereafter.

To summarize, forecasts of automobile travel and total consumption of gasoline indicate an initial period to the mid-1980s of stable or declining activity, which, along with fuel efficiency improvements, mean reduced requirements for gasoline. In the latter part of the decade, the effect of price and cost increases will soften, resulting in growth in traffic and a resumption in the growth of demand for fuel. Gasoline consumption forecasts are contained in Tables 37 and 38 for the two scenarios.

7.5.3 Diesel

Consumption of diesel was 16.5% of the total of all fuels in 1980, up from 11% in 1970 (see Table 35). Fuel efficiency improvements have been made, but at the same time there has been considerable switching to diesel from gasoline. By 1990, for example, almost all trucks, which accounted for more than half the diesel consumed in 1980, likely will be diesel-powered.

To produce forecasts of diesel consumption, past trends were analyzed, technological change assessed, and relationships established between fuel consumption, output and prices. The objective was to incorporate DGEA freight and passenger output forecasts as well as the fuel prices for the two scenarios.

The pattern of expected diesel consumption over the decade is similar to that for gasoline, with no growth in the first half of the period, followed by strong growth (see Figure 7). This

FIGURE 6

TOTAL ROAD GASOLINE CONSUMPTION, MILLION LITRES, 1970-90

(millions of litres)

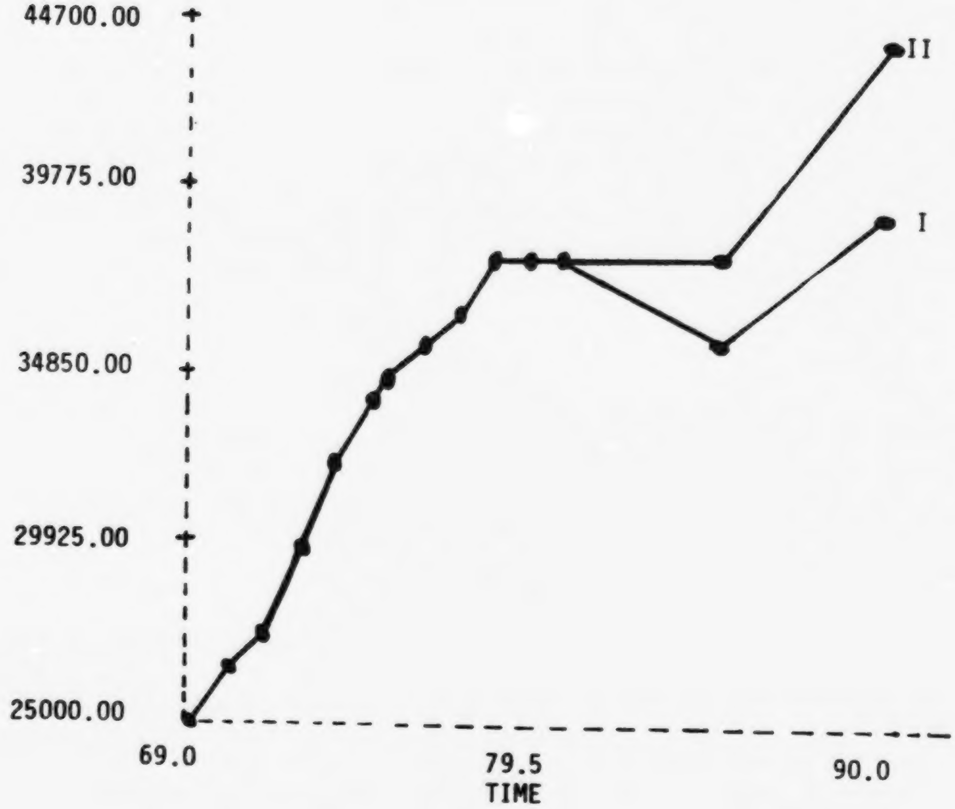


TABLE 37

TRANSPORT FUEL CONSUMPTION BY TYPE OF FUEL - SCENARIO I

Fuel	1980	1985	1990
		(million litres)	
Gasoline	38,477	36,000	39,400
Diesel	9,052	9,200	10,600
Heavy Fuel Oil	2,444	2,500	2,650
Turbo	4,575	3,550	3,650
Aviation Gasoline	238	230	230
TOTAL	54,780	51,480	56,530
		(percent of total)	
Gasoline	70.2	69.9	69.7
Diesel	16.5	17.9	18.8
Heavy Fuel Oil	4.5	4.9	4.7
Turbo	8.4	6.9	6.5
Aviation Gasoline	0.4	0.4	0.4
TOTAL	100.0	100.0	100.0
	1980-85	1985-90	1980-90
		(total percentage change)	
Gasoline	-6.4	9.4	2.4
Diesel	1.6	15.2	17.1
Heavy Fuel Oil	2.3	6.0	8.2
Turbo	-22.4	2.8	-20.2
Aviation Gasoline	-3.5	-	-3.5
TOTAL	-6.0	9.8	3.2

TABLE 38

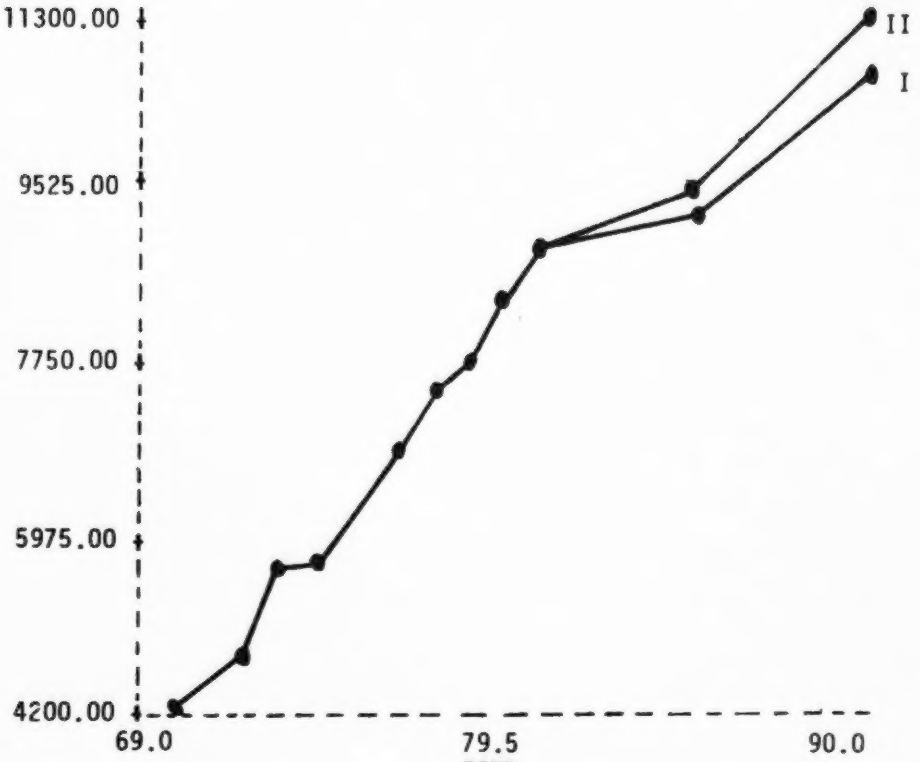
TRANSPORT FUEL CONSUMPTION BY TYPE OF FUEL - SCENARIO II

Fuel	1980	1985	1990
		(million litres)	
Gasoline	38,477	38,300	44,700
Diesel	9,052	9,500	11,300
Heavy Fuel Oil	2,444	2,500	2,650
Turbo	4,575	4,100	4,800
Aviation Gasoline	238	230	230
TOTAL	54,780	54,630	63,680
		(percent of total)	
Gasoline	70.2	70.1	70.2
Diesel	16.5	17.4	17.7
Heavy Fuel Oil	4.5	4.6	4.2
Turbo	8.4	7.5	7.5
Aviation Gasoline	0.4	0.4	0.4
TOTAL	100.0	100.0	100.0
	1980-85	1985-90	1980-90
		(total percentge change)	
Gasoline	-0.5	16.7	16.2
Diesel	4.9	18.9	24.8
Heavy Fuel Oil	2.3	6.0	8.4
Turbo	-10.4	17.1	4.9
Aviation Gasoline	-3.5	-	-3.5
TOTAL	-0.3	16.6	16.2

FIGURE 7

TOTAL DIESEL CONSUMPTION, 1970-90

(millions of litres)



reflects the different fuel price increases and rates of economic growth anticipated in the two parts of the period.

Also, as explained in Section 6.4, much of the traffic by rail and marine is relatively insensitive to alternate fuel price scenarios. The rate of introduction of new fuel-efficient technology in these modes is also slower and less flexible than for many road vehicles. The differences in consumption of diesel expected between the two scenarios is therefore almost entirely attributed to road vehicles, excluding for-hire trucks. An easing in fuel prices, as assumed in the second scenario, would reduce the incentive for bus and light truck operators, for example, to conserve fuel and improve efficiency.

Total diesel consumed under the base-case scenario is expected to be 9,200 million litres in 1985, up 1.6% from 1980, and 10,600 million in 1990, a 17% increase over the 1980 level (see Table 37). The more likely scenario of lower fuel prices results in a 4.9% increase to 1985 and a 25% increase over the 10 years (see Table 38).

The forecasts were produced individually for total rail, for-hire trucking, marine and the residual. Traffic forecasts described above in Chapter 6 were incorporated in models, which also included fuel prices. The major deficiency in the analysis was a lack of data on road vehicles accounting for the residual diesel consumption. For this category, consumption was related to per capita disposable income and fuel prices, with a 10% improvement in fuel efficiency assumed to occur over the decade.

7.5.4 Other Fuels

The method used to forecast the consumption of heavy fuel oil, turbo and aviation gasoline was similar to that used for diesel. Models[3] were developed in which consumption was dependent on traffic in the particular mode and the price of fuel. To generate forecasts, then, traffic forecasts (from Chapter 6) and fuel price forecasts (from Chapter 3) are inserted into the equation and fuel efficiency improvements applied. Compared with base-year fuel efficiency factors, increased activity will be possible using the same amount of fuel, so that new fuel efficiency factors will be as stated in Table 21.

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[3] DGEA, op.cit., November 1981

For example, the consumption of aviation turbo fuel was found to be closely related to the number of passengers carried and to the real price of turbo. Forecasts of passengers[4] were produced under the two energy price scenarios and these, together with forecasts of turbo prices and expected improvements in fuel efficiency in air operations, resulted in a projected decrease in consumption of 20% from 1980 to 1990 under the first scenario and an increase of 5% over the decade under the second scenario. The pattern of recovery in growth in the second half of the 1980s, following an initial period of substantial decline, re-occurs here.

The "low" traffic forecasts for turbo are contained in Tables 37 and 38 for the two energy price scenarios, along with forecasts for heavy fuel oil and aviation gasoline. Heavy fuel oil consumption by the marine sector is expected to rise by 8.4% to 1990, and to be unaffected by energy prices. The use of this fuel was analysed with diesel fuel for the marine mode and a constant share of the total assumed for each fuel. Similarly, consumption of aviation gasoline was considered along with turbo fuel, but on the basis of historical evidence was assumed to remain constant over the forecast period. Further work is required in analysis of the use of these fuels and the likelihood of future switching, but because their totals are insignificant with respect to all fuels consumed, these assumptions were considered acceptable for this study.

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[4] Alternative scenarios on air passenger movements were included in the 1982 Strategic Planning Guidelines. These result in 0.5% growth per year in turbo fuel consumption, as shown here under Scenario II energy prices, 2.3% annual growth for "medium" traffic growth, and 3.2% for the "high" case. Use of the latter two scenarios, which result in greater fuel consumption, strengthens the conclusion of this report that NEP target levels for transport fuel use will be exceeded by 1990.

7.6 Total Fuel Consumption

Over the first half of the forecast period (to 1985) total fuel consumed is expected to fall 6% below the 1980 level under NEP/Agreement prices, and fall hardly at all under the scenario of lower fuel price increases. These results are contained in Tables 37 and 38, and illustrated in Figure 8.

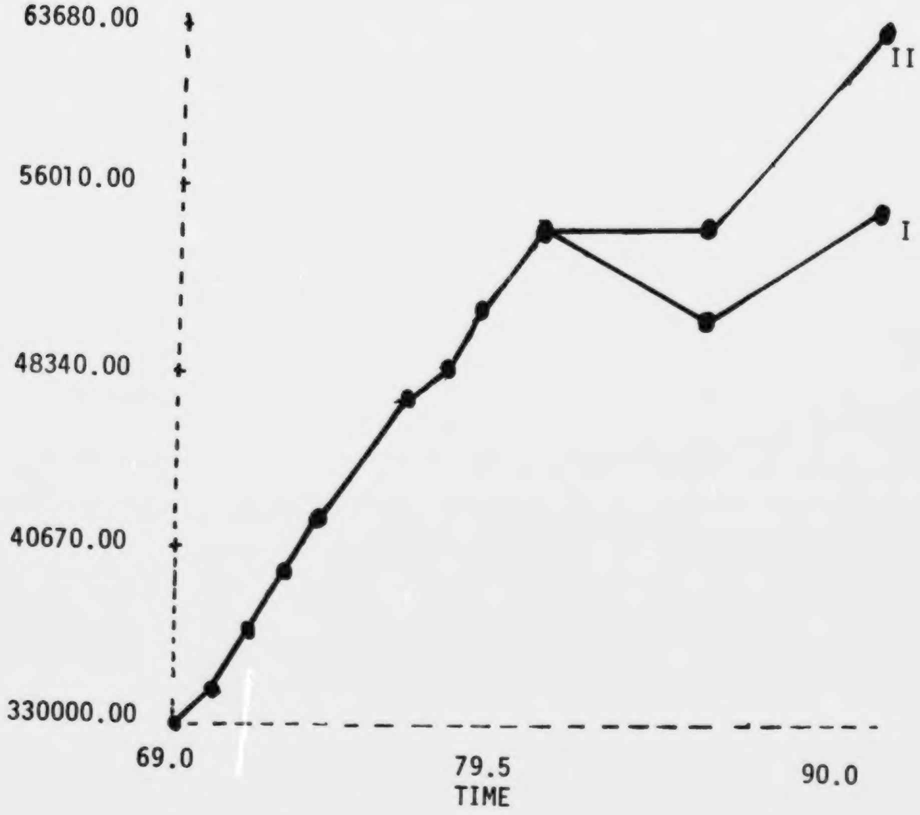
Thus, as Canadians adjust to world oil prices by the mid-1980s, the target of zero growth in fuel consumption by the transport sector should be attainable. By 1900, however, combined fuel use in the sector is expected to be 3.2.% above 1980 total consumption in the first scenario and 16.2% higher in the second scenario. The chances of maintaining fuel use at 1980 levels are not good considering that the lower fuel price increases to be more realistic from the present perspective (they should be even lower according to some observers). Even with more successful off-oil program than was envisaged in the NEP, e.g., 50,000 barrels a day instead of 21,000 barrels a day, or a reduction by 1990 of approximately 2.9 billion litres, there likely will be an 11% increase in oil products consumed by transport, under the lower price sceanrio. Such a switch of oil would, however, be sufficient to cause zero growth under NEP/Agreement price increases.

Growth in total fuel use is similar to growth in gasoline alone, with the latter accounting for 70% of the total. If the same amount of turbo fuel were to be consumed in 1985 as in 1980 (almost 30% more than given in Table 37), the total of all fuels consumed would be just two percentage points less, at 4% instead of 6%.

FIGURE 8

TOTAL FUEL CONSUMPTION, 1970-90

(million of litres)



8. CONCLUSIONS

There will be no growth in fuel consumption in the next few years owing to drastic energy price increases now faced by the transport sector, as Canada adjusts to world prices, and the substantial improvements in fuel efficiency (especially for the automobile). It is likely, however, that economic conditions after 1985 will favour a resumption of relatively strong growth in fuel requirements, so that 1980 levels will be well exceeded by 1990.

The future world energy prices envisaged by the National Energy Program and Alberta Agreement (first scenario), now appear unlikely. Thus, a second scenario was used to show what might happen if, by 1990, the international price of crude oil at Montreal were more than 25% lower than in the first case.

The effect of this lower price is an almost 13% higher level of fuel consumption by the transport sector in 1990. If the NEP target of zero growth from 1980 levels is to be achieved, therefore, prices at least as high as those assumed in the NEP will have to occur.

A broader objective of the NEP was oil self-sufficiency by 1990. To achieve this, three strategies were promoted: an increase in the domestic supply of oil, an increase in the availability and attractiveness of alternate fuels, and a reduction in demand. This study has dealt only with the latter and, moreover, only with a portion of demand, that by the transport sector. It may well be that the rest of the Program is successful to the extent that the target for transport is flexible. In an even larger context, the energy goal itself might assume less priority, with success in conservation programs and as non-energy concerns become more prominent.

So long as the NEP target for the transport sector remains firm, this study implies that policies will have to be considered to induce the desired long-term level of fuel consumption. The responsiveness of transport fuel use to energy prices, as one potential policy instrument, is evident from this study.

In addition to the need for ongoing analysis and monitoring of transport fuel consumption, a number of requirements for further research have emerged during the study. More data and information on road vehicles is needed, and better modeling of both vehicle use and fuel consumption by automobiles is recommended. Further examination and development of urban transport data and analysis is needed, as is a more rigorous approach to projecting the rate of introduction of new fuel-saving technology. The price and cost forecasting methods also need refinement and further development.

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